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# PESTICIDE RESEARCH PROJECTS

**Funded by the Ministry  
of the Environment  
through the Ontario  
Pesticides Advisory  
Committee**

1985 - 86



**The Ontario  
Pesticides  
Advisory Committee**

**Hon. Jim Bradley  
Minister  
Rod McLeod, Q.C.  
Deputy Minister**



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THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1985 - 1986



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PESTICIDE RESEARCH PROJECTS FUNDED BY THE MINISTRY OF THE ENVIRONMENT  
THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1985-86

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## EXECUTIVE SUMMARY

1. In 1985-86, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The objectives of the program are:
  - (a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.
  - (b) To determine potential environmental hazards with pesticides currently in use.
  - (c) To reduce pesticide input into the environment.
2. The research budget was \$400,000.
3. Sixty-one research proposals totalling \$900,910 were received.
4. Thirty proposals were funded with a total value of \$391,526. Awards averaged \$13,051, and ranged from \$6,650 to \$32,162.
5. Three grants totalling \$27,500 were awarded for studies on development of alternative pesticides.
6. Seven grants totalling \$124,587 were allocated to studies on the behaviour and fate of pesticides in the environment and on potential environmental hazards to non-target organisms.
7. Twenty grants totalling \$239,439 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.
8. The Pesticides Advisory Committee is very satisfied with the research progress in 1985-86. It recognizes that, with the funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines.
9. The Pesticides Advisory Committee recommends that:
  - i) The Ministry of the Environment continue to support research programs directed toward development of pest control programs which will not pose any serious environmental hazard.
  - ii) The Pesticides Advisory Committee continue to supervise the program following guidelines which have been developed.



## I. OBJECTIVES

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee (OPAC) to sponsor pesticide-related research in 1973. Terms of Reference developed by OPAC to govern the awarding of research grants are based on three general objectives:

- 1) To find alternative pesticides for those deemed environmentally hazardous and thus restricted for use.
- 2) To determine potential environmental hazards with pesticides currently in use.
- 3) To reduce pesticide input into the environment.

An "Application for Research Support", which invites research proposals in several specific areas relating to the program objectives is reviewed and revised annually by OPAC in consultation with the Ministry of the Environment Research Advisory Committee. In 1985-86, research proposals were invited in six specific areas relating to the three research objectives (Appendix I).

## II. SELECTION PROCEDURE

Notices inviting applications for research support were widely distributed in January, 1985 to researchers and administrators in Ontario universities, industry, government, and other organizations, with the deadline for receipt of applications being February 28, 1985. In March, 56 applications were considered by the OPAC Research Subcommittee comprising eight members (R. Frank, J.C. Ingratta, B.H. McGauley, J.J. Onderdonk, E. Piche, K.R. Solomon, G.R. Stephenson, and C.R. Harris (Chairman)), all with a broad knowledge of pesticides and problems of pest control. Criteria used in judging applications included: 1) applicability to research objectives; 2) scientific quality of research proposal; and 3) ability of applicant(s) to carry out research as proposed. Five applications were received later in the year and were similarly considered. Recommendations prepared by the Research Subcommittee were reviewed by the entire Pesticides Advisory Committee. OPAC recommendations were then forwarded to the MOE Research Advisory Committee for confirmation and funding. Funds were made available to most grant recipients by June, 1985.



### III. PROJECTS SUPPORTED

The OPAC research budget in 1985-86 was \$400,000.

Sixty-one research proposals totalling \$900,910 were received. Most (42) were from universities/colleges (Brock, Carleton, Guelph, Ottawa, Sault College of Applied Arts and Technology, Toronto, Trent, Western, and York). The remaining applications were submitted by industry or other organizations. Thirty proposals (Appendix II) were accepted. Awards averaged \$13,051 (range \$6,650 to \$32,162). Disbursement of research funds by organization is summarized below:

Organization	Number of Research Grants Awarded	\$ Total Research Funds
University of Guelph	14	193,418
University of Western Ontario	4	50,381
University of Toronto	1	15,245
Sault College of Applied Technology	1	17,420
Trent	1	16,050
Other	9	99,012
<b>TOTAL</b>	<b>30</b>	<b>391,526</b>

Results obtained in the various studies are summarized in Appendix III. Three grants (Abstract #17, 21, 22) totalling \$27,500 were awarded for studies on development of alternative pesticides for those deemed environmentally hazardous and thus restricted in use. Seven grants (Abstract #3, 4, 7, 8, 11, 20, 24) totalling \$124,587 were allocated for studies to determine potential environmental hazards with pesticides presently in use. Twenty grants (Abstract #1, 2, 5, 6, 9, 10, 12, 13, 14, 15, 16, 18, 19, 23, 25, 26, 27, 28, 29, 30) totalling \$239,439 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

### IV. ACCOUNTABILITY

Direction and progress of the research were monitored by OPAC in several ways. Initially, some applicants were asked to modify their proposals to better meet the research guidelines. In several instances, OPAC members met with applicants to discuss their research proposals and to suggest modifications where necessary. In June, 1985, as a part of the Annual OPAC



field trip, visits to some of the researchers receiving financial support were included on the agenda, thus giving OPAC members an opportunity to become acquainted with cooperating scientists and research in progress. Informal contacts between OPAC members and grant recipients were established and maintained throughout the year. In January, 1986, OPAC sponsored a two-day meeting at which grant recipients presented their research results. This meeting was attended by OPAC members and more than 80 guests interested in pesticide-related research. In addition, grant recipients were required to provide OPAC with a summary of progress (Appendix III) and, where necessary, a comprehensive project report.

Research reports, manuals, theses, etc., published in 1985-86 relating to OPAC sponsored research are listed in Appendix IV.

#### V. RECOMMENDATIONS

The Pesticides Advisory Committee is pleased with research progress made in 1985-86. The Committee recognizes that with the funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines. The Committee recommends that:

- (1) The Ministry of the Environment continue to support this very productive research program directed toward development of pest control programs which will not pose any serious environmental hazard.
- (2) The Ontario Pesticides Advisory Committee continue to supervise this program following the guidelines which have been developed. With its broad expertise, strong scientific background and close liaison with the scientific community, OPAC is in the unique position of being able to define research priorities and to ensure that excellent value is received for money spent.



## APPENDICES



APPENDIX I: FORMAT OF ADVERTISEMENT INVITING APPLICATIONS FOR RESEARCH  
SUPPORT FROM THE ONTARIO PESTICIDES ADVISORY COMMITTEE

APPLICATION FOR RESEARCH SUPPORT

January 1985

The Ontario Ministry of the Environment through the Pesticides Advisory Committee has a limited amount of funds available for 1985 to sponsor research aimed at: (1) developing alternative pesticides for those deemed environmentally hazardous and thus restricted in use; (2) determining potential environmental hazards associated with pesticides currently in use; and (3) developing alternative approaches to pest control in order to reduce total pesticide input into the environment. Preference will be given to proposals yielding results in a relatively short time, with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Economics of pest<sup>[1]</sup> control including development of crop loss estimates and determination of economic thresholds of damage.
2. Studies leading to development of environmentally acceptable pesticides<sup>[2]</sup>, for use in structures or for the protection of food and fibre.
3. Reduction of pesticide use through development of pest monitoring techniques; improved application procedures; or integrated or non-chemical methods of pest control.
4. Development of efficient techniques of pesticide application.
5. Development of information on time which should elapse between dates of treatment and re-entry into treated areas including buildings, and on exposure of agricultural, horticultural, and forestry workers, licensed exterminators, and the public to pesticides.
6. Studies on the persistence, degradation, mobility, and biological significance of pesticide residues in the environment<sup>[3]</sup>.

APPLICATION PROCEDURES

Research proposals should be submitted to:

Dr K.A. Howard  
Chairman  
Pesticides Advisory Committee  
Ministry of the Environment  
Suite 100, 135 St. Clair Avenue West  
Toronto, Ontario M4V 1P5

Applications should be received by February 28, 1985, and should include the following:

1. Title of project.
2. Name, address and affiliation of applicant(s).
3. Discussion of problem.
4. Clear statement of objective(s).
5. Plan for program.
6. Facilities available.
7. Budget - categorize costs as: Personnel - full/time and part/time, Equipment, Supplies, Overhead Costs, Other.
8. Listing of current projects and other sources of funding.
9. Curriculum vitae on principal investigator(s), including list of papers published over the past 5 years.

Successful applicants must submit an abstract by year's end and present a progress report at the Committee's annual research seminar held each January. A financial report may be required at the discretion of the Ministry of the Environment.

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[1] "**Pest**" means any injurious, noxious or troublesome plant or animal life other than man or plant or animal life on or in man and includes any injurious, noxious or troublesome organic function of a plant or animal (Pesticides Act, Chapter 376, S.1 (1)(s)).

[2] "**Pesticide**" means any organism, substance or thing that is manufactured, represented, sold or used as a means of directly or indirectly controlling, preventing, destroying, mitigating, attracting or repelling any pest or of altering the growth, development or characteristics of any plant life that is not a pest and includes any organism, substance or thing registered under the Pest Control Products Act (Canada); (Pesticides Act, Chapter 376, S.1. (1) (t)).

[3] "**Environment**" means the natural environment, (air, land and water) a building, structure, machine and vehicle, or any of them (Pesticides Act, Chapter 376, S.1 (1) (e) and (n)).

APPENDIX II: RESEARCH PROJECTS SUPPORTED BY THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1985-86

No.	APPLICANT (S)	AFFILIATION	PROJECT TITLE	\$ AMOUNT GRANTED
1.	Biggs, A.R.	Ontario Tender Fruit Products Marketing Board	Application of epidemiology to reducing fungicide requirements for controlling brown rot on stone fruits.	6,650
2.	Burpee, L.	University of Guelph	Reduction of fungicide requirements for dollarspot disease on turfgrass: Implementation of modified nitrogen application programs.	8,935
3.	Buttle, J.M.	Trent University	Field monitoring of the hydrologic pathways of herbicide transport.	16,050
4.	Chapman, R.A. Harris, C.R.	University of Western Ontario	Persistence and degradation in soil of insecticides recommended in Ontario for corn rootworm control.	20,365
5.	Edgington, L.V.	University of Guelph	Biological and chemical control of onion white rot in muck soil.	10,100
6.	Ellis, C.R.	University of Guelph	Development of suitable monitoring methods and economic thresholds for corn rootworms.	18,190
7.	Goldberg, M.T.	University of Guelph	A study of the in vivo genotoxicity of captan in the mammalian duodenum.	16,350
8.	Hall, J.C. Stephenson, G.R.	University of Guelph	Lateral movement of 2,4-D and mecoprop from grassy inclines.	32,162

No.	APPLICANT(S)	AFFILIATION	PROJECT TITLE	\$ AMOUNT GRANTED
9.	Hubbes, M. Wallace, D.R. Smith, S.M.	University of Toronto	Feasibility of using releases of <u>Trichogramma minutum</u> for biological control of <u>Choristoneura</u> species.	15,245
10.	Jarvis, W.R.	Southwestern Ontario Agricultural Research Corporation	Biological and integrated control of cucumber powdery mildew: The enhancement of antagonistic microbial populations and the role of adjuvants.	20,400
11.	Kaushik, N.K.	University of Guelph	Toxicity of pentachlorophenol to zooplankton: Fate and effects.	14,100
12.	Laing, J.E. Heraty, J.M.	University of Guelph	Introduction of <u>Holcothorax testaceipes</u> (Hymenoptera: Endyrtidae) for the biological control of spotted tentiform leaf miner, <u>Phyllonorycter blancardella</u> (Lepidoptera: Gracillariidae).	15,047
13.	Madder, D.J. Steneroff, M.	Culice, and Steneroff and Associates	A study of integrated pest management programs on muck crops in Ontario.	8,977
14.	Madder, D.J. Steneroff, M.	Culice, and Steneroff and Associates	The feasibility of implementation of an integrated pest management program on field tomatoes in Ontario.	15,100
15.	Makey, S.R. Leili, H.J.	H.J. Heinz Co. of Canada Ltd.	Weather timed fungicide application on tomatoes for improved disease control.	8,000

No. APPLICANT (S)	AFFILIATION	PROJECT TITLE	\$ AMOUNT GRANTED
16. Nealis, V.G.	Sault College of Applied Arts and Technology	Development of survey techniques to estimate the impact of parasites on overwintering populations of the spruce and jack pine budworms.	17,420
17. Pree, D.J.	Ontario Apple Marketing Commission	Genetics and management of acaricide resistance in the European red mite.	9,000
18. Sears, M.K.	University of Guelph	Crop loss associated with pests of canola in Ontario.	9,058
19. Sears, M.K.	University of Guelph	Thresholds of Colorado potato beetles and potato leafhoppers on potatoes.	7,902
20. Siddiqi, Z.	Chemical Research International	Chlorpyrifos and propoxur residues in air after application for structural pest control.	7,400
21. Siddiqi, Z.	Chemical Research International	Monitoring litter size and duration of breeding of the meadow vole, <i>Microtus pennsylvanicus</i> , in relation to nutrition (body weight) to schedule control regimes.	8,500
22. Souza Machado, V.	University of Guelph	Efficacy and degradation of alternative herbicides to allidochlor in onions.	10,000
23. Stemeroff, M.	Stemeroff and Associates	A study of the costs and benefits of herbicide use on corn and soybeans in Ontario.	14,985
24. Stephenson, G.R. Solomon, K.R.	University of Guelph	Lateral movement of picloram + 2,4-D in soil.	18,160

No. APPLICANT(S)	AFFILIATION	PROJECT TITLE	\$ AMOUNT GRANTED
25. Surgeoner, G.A.	University of Guelph	The economics and efficacy of sanitation for house fly control in dairy and swine barns.	6,958
26. Sutton, J.C.	University of Guelph	Integrated practices for managing botrytis grey mold in strawberries.	14,706
27. Teal, P.E.A. Quiring, D.T.W	University of Guelph, and Southwestern Ontario Agricultural Research Corporation	Development of semiochemical based mass trapping programs for control of chrysomelid beetles.	11,750
28. Tolman, J.H. McLeod, D.G.R.	University of Western Ontario	Losses in production of processing tomatoes attributable to insects, diseases and weeds.	6,860
29. Tomlin, A.D. Whistlecrafft, J.W.	University of Western Ontario	Biology of the dipterous predator <u>Coenosia tigrina</u> F.	10,856
30. Tu, C.M. Turnbull, S.A. Harris, C.R.	University of Western Ontario	Feasibility of using <u>Entomophora muscae</u> to control selected dipterous insect pests.	12,300
TOTAL			\$391,526

APPENDIX III: SUMMARY PROGRESS REPORTS FOR PROJECTS FUNDED BY THE ONTARIO  
PESTICIDES ADVISORY COMMITTEE, 1985-86

1. BIGGS, A.R. and NORTHOVER, J. - Application of epidemiology to reducing fungicide requirements for controlling brown rot of stone fruits.

Field and laboratory studies on the epidemiology of brown rot of stone fruits continued in 1985. The overall objective of this project is to reduce the number of fungicide applications used to control brown rot in Ontario stone fruit orchards.

Temperature-wetting conditions conducive to infection of sweet cherry fruits by conidia of *M. fructicola* were determined. Experiments were conducted with the cultivars Vista and Bing using the tray and screen system described previously. The experiment was devised to test 7 temperatures (15 to 30°C in 2.5°C increments) in all combinations with 5 wet periods (6 to 18 hours in 3 hour increments).

Percent infection and latent period were the two parameters examined in this system. Latent period was defined as the number of hours it takes for 50% of the infected fruit to show visible sporulation. Knowledge of latent period effects could be useful in timing application of post-infection or antisporeulant type fungicides. For the cultivar Vista, the most infection took place at 22.5 and 25°C, the least at 15 and 30°C. However, hours of fruit wetness was the most important factor influencing the amount of infection in these experiments. At least 9 hours of wetness was required to achieve infection significantly greater than the non-inoculated control. For the cultivar Bing, the most infection took place at 20 and 22.5°C and the least at 30°C. Again, hours of fruit wetness was the over-riding significant effect with 9 hours of wetness required to produce significant infection.

Using the percent infection data combined for both cultivars, a multiple regression equation was formulated to predict percent fruit infection from hours of fruit wetness and mean temperature during the wet period. This model needs to be tested to determine its usefulness, for the time being wet periods longer than 6 hr should be considered conducive for infection. In earlier studies with injured fruit, it was observed that infection could take place in 4 hr.

In our examinations of latent period, significant fruit wetness time effects were observed. These effects were not significantly different for the two cultivars. Fruit that were wet for 9 hours took about 36 hours longer to reach the latent period than fruit wet for 18 hours. It appears that when infection periods are relatively short, growers could have an extra day and a half to apply antisporeulant materials, such as Benlate, or the new sterol inhibiting compounds if they became registered for applications on mature fruits.

A second laboratory experiment was designed to investigate the influence of inoculum density on the incidence of infection. As before, the data were collected as percent infection and latent period in hours. The time required for infection was significantly reduced as spore numbers increased. With respect to latent period, the percent of inoculated fruit showing visible sporulation was also influenced by inoculum density. For example, at 1 million spores per ml roughly 50% of the fruit were sporulating in three days versus nine days at inoculations with ten thousand spores.

Orchard spore load probably has a significant effect on rate of infection, rate of fungus reproduction, and when weather favors disease, rate of disease spread. These data emphasize the importance of orchard sanitation and the need to keep spore population numbers as low as possible to maximize the effect of a reduced fungicide program for brown rot control.

Our field studies this year were not as successful as expected due to extremely dry weather during much of the summer. September rains favoured brown rot infection and some information was obtained from the late season cultivars Cresthaven (fresh market free stone) and Babygold 7 (processing clingstone).

The object of this field study was to examine the influence of orchard floor management on the incidence of brown rot in mature peach fruit. Eight orchard sites were selected and grouped in pairs according to geographic location. In each site pair, one site was managed using clean cultivation followed by a cover crop, and the second site was permanent sod with a herbicide strip and supplemental irrigation. Brown rot incidence on 300 fruit per block, 3 blocks per site, was assessed at weekly intervals in September. There were extremely low levels of brown rot infection and, although disease incidence appeared higher in peaches under sod culture, no statistically significant differences due to orchard floor type could be discerned.

## **2. BURPEE, L.L., and GOULTY, L.G. - Reduction of fungicide requirements for dollarspot disease on turfgrass. Implementation of modified nitrogen application programs.**

Experiments were designed to develop an acceptable nitrogen-fungicide management scheme for control of dollarspot disease of creeping bentgrass. Results of field studies indicated that the incidence of dollarspot was directly related to the amount of sulfur-coated urea applied. Disease ranged from 43% on turf that received 25 kg N/ha/mo to 13% on turf that received 75 kg N/ha/mo. Applications of the fungicide Daconil 2787 at 3 kg a.i./ha provided unacceptable control of dollarspot on turf that received 25 kg N/ha/mo. However, the same rate of fungicide provided acceptable control on turf that received 38 kg N/ha/mo or more.

In another group of experiments, the duration of acceptable control of dollarspot increased in proportion to the amount of soluble urea applied to creeping bentgrass. For example, 3 days of acceptable control was observed on turf that received 5.7 kg N/ha/mo and 10 days control was observed on turf treated with 23 kg N/ha/mo. An unexplained antagonistic reaction was observed between Daconil 2787 and urea when the two chemicals were tank-mixed and applied to turf. The duration of control obtained with the tank-mix was less than that obtained with Daconil or urea alone.

The results of these studies indicate that the use of sulfur-coated urea in a dollarspot management program can lead to reduced fungicide requirements. It is estimated that increasing S.C.U. applications from 25 kg N/ha/mo to 38 kg N/ha/mo can save from \$41.00 to \$70.00/ha in fungicide costs and reduce fungicide usage by 2 to 3 kg a.i./ha. The results also indicate that the application of soluble ureas may have potential as a means of managing dollarspot. However, tank-mixing urea with the fungicide Daconil 2787 results in a reduction in disease suppression potential.

### 3. BUTTLE, J.M. - Field monitoring of the hydrologic pathways of herbicide transport.

This project was funded in early 1986. Objectives are:

- A) To conduct a comprehensive literature search on the hydrologic pathways of herbicide movement to receiving water bodies.
- B) To design and test a practical and detailed system for the monitoring and evaluation of herbicide movement, from application to entry into receiving water bodies. The herbicide metolachlor will be selected for study, owing to its use in agriculture in Ontario, its high water solubility, and its possible contamination of domestic water supplies.

A progress report is expected in 1987.

### 4. CHAPMAN, R.A. and HARRIS, C.R. - Persistence and degradation in soil of insecticides recommended in Ontario for corn rootworm control.

Corn rootworms are the major soil insect problem in North America. Although they can be managed by crop rotation, this control method is often not considered feasible. Chemicals offer an alternative; current recommendations involve application of one of several organophosphorus or carbamate insecticides, usually applied as a banded application at planting. In Ontario, insecticides applied to control rootworms probably represent the largest single insecticide use.

Rootworms are present in soil from about the middle of May until the end of July and insecticides applied at planting must be sufficiently persistent to remain biologically active through the larval stage. Insecticides currently recommended for rootworm control do not always perform as well as expected. In part, erratic efficacy can be attributed to such factors as poor equipment calibration, careless application, and the effect of soil and climatic factors on insecticide toxicity. Persistence of the insecticide in soil also is of critical importance. Comparative data on the persistence of rootworm insecticides in soil are lacking.

In 1983, we initiated a comprehensive 3-year comparative persistence study on insecticides recommended or being evaluated for corn rootworm control. The study was set up in microplots on the London Research Centre Field Station. Using a clay loam soil which had not been previously subjected to pesticide treatment, granular insecticides were applied at recommended application rates (usually 11.0 - 11.3 g AI/100 m row) to each plot in 3 15 cm bands. Treatments were replicated. After application, the treatments were lightly incorporated by gentle raking parallel to the length of the band. Three corn seeds were planted at the ends and in the centre of each row to simulate normal field conditions. Soil samples (2.5 x 15 cm cores) were taken through the bands at 0,1,2,3,4,6,8,10,12,16, and 20 wk; the insecticide residues (parent materials and toxic metabolites) were extracted and analyzed by GC or HPLC. In most instances plots treated in 1983 were retreated with the same insecticide in 1984 and 1985. In 1985, an additional set of plots was established to obtain a comparison of "first year" persistence in previously untreated soil with the persistence of the same insecticide after 3 consecutive years treatment. In 1985, vertical mobility of some of the insecticides in soil and the relative persistence of pre- and post-planting applications also received attention.

During the 3-year period, the persistence of 15 insecticides in soil was investigated. These included 9 insecticides registered for corn rootworm control and 6 experimental insecticides. In general, >80% of the initial planting-time insecticide application dissipated during the first 8 weeks after treatment. Of the recommended insecticides, the persistence of chlorfenvinphos (now withdrawn) and disulfoton appeared to be marginal. Four (Dowco 429x, PP993, SD208304, trimethacarb) of 6 experimental insecticides appeared sufficiently persistent to merit further evaluation for corn rootworm control.

When published rootworm insecticide toxicity data were considered, the residue data indicated that, on average, recommended insecticides persisted just long enough under normal conditions to provide the required level of biological activity. However, persistence varied considerably from year to year and from insecticide to insecticide; chlorpyrifos (avg. 8 wk residue = 0.5 ppm; range 0.3 - 0.7 ppm), fonofos, phorate, and terbufos were more consistent than carbofuran or isofenphos (avg. 2.2 ppm; range 6.6 - 0.0 ppm) (now withdrawn).

On application, a corn rootworm insecticide is concentrated in the upper layer of soil. Tests with 3 insecticides (chlorpyrifos, terbufos, carbofuran) with widely varying solubilities in water indicated that vertical movement was very limited in all cases; residues of all 3 insecticides remained largely in the upper 5 cm of the soil.

A banded application of chlorpyrifos granular applied 4 weeks after planting resulted in significantly higher residues in soil 8 weeks after planting as compared to the normal planting-time application. If effective and practical, post-planting applications could yield higher levels of insecticide residues in the soil during the period of larval activity.

Field and laboratory studies indicated that soil microorganisms are capable of adaptation to rapid degradation of carbofuran and other methyl carbamate insecticides in soil and of organophosphorus insecticides such as fensulfothion and isofenphos. Laboratory studies indicated that development of anti-carbofuran activity in soils and of subsequent degradation of carbofuran in activated soils is dependent on formulation, application rate, soil type, and climatic conditions. These data provide an explanation for the erratic persistence of carbofuran and isofenphos in soil.

To date this work has resulted in publication of 5 research papers. Results have also been presented at 3 OPAC Research Seminars; numerous meetings of growers, pesticide dealers, or extension specialists; and in invitation seminars at industrial research laboratories in the United States.

## 5. EDGINGTON, L.V. and VALDES, E. - Biological and chemical control of onion white rot in muck soil.

### A) Biological Control

The parasitic activity of two isolates of Sporidesmium sclerotivorum on sclerotia of the onion white rot fungus was tested in the field during the 1985 season. Twenty-four enclosed microplots (1.6 m<sup>2</sup> each) located at the Arkell Research Station were filled with muck soil and infested with sclerotia (10 sclerotia/g soil). Sporidesmium was applied as a soil drench of a conidial suspension (1000 conidia/g soil). The two Sporidesmium isolates used, CS-29 and CS-18 were effective parasites of sclerotia under laboratory conditions at 25°C. However, Sporidesmium failed to parasitize sclerotia in the field.

Temperature, one of the most important factors for the growth of Sporidesmium may have been too low in soil of plots for the establishment of this parasite. Experiments are being conducted in growth chambers to verify whether temperature was the factor that limited the growth of Sporidesmium in the field.

## B) Chemical Control

Chemical control of onion white rot with dichloran (Botran®) was tested at the Muck Research Station at Bradford. A 70 m<sup>2</sup> enclosed plot infested with viable sclerotia was used. Dicloran was applied to the soil as a coarse spray, 10 days before planting onions. Two concentrations were used, low (6.75 kg/ha), high (11 kg/ha), and the control (no fungicide applied). At the end of the season all the plants were pulled to determine the incidence of white rot. However, all of 2000 onion plants, including those in the control plots, were healthy and no symptoms of the disease were detected.

After harvest, a test was conducted to determine the viability of the sclerotia. The results obtained indicated that sclerotia had lost their viability; many were hollow or if apparently intact, they disintegrated when touched with forceps. A review of the history of the plot indicated that this area was flooded at the beginning of the season. The effect of flooding on sclerotia survival is therefore being investigated.

## 6. ELLIS, C.R. - Development of suitable monitoring methods and economic thresholds for corn rootworms.

A) Monitoring adult corn rootworms as a basis for pest management in field corn. (H.J. McAuslane and C.R. Ellis)

This is the second report on the monitoring portion of the project. The Ontario Ministry of Agriculture and Food is committed to a five-year plan to implement a pest management program on field corn in Ontario. Pest management is likely to have a significant impact on pesticide use in Ontario. Unfortunately, a suitable monitoring program to serve as a basis of the pest management program was not available. The general objective of the research reported here was to develop a quick, reliable and cheap monitoring method to enable rootworm management.

Considerable information has been published on monitoring methods for corn rootworms in field corn. Unfortunately, we did not know which method of monitoring was most suitable to our Ontario conditions in terms of equipment, cost, time required, and reliability of the prediction for the two species of rootworms. Our specific objectives were to: 1) compare five monitoring methods and to find the most efficient and inexpensive; 2) determine the feasibility of monitoring with traps baited with sex pheromone; and 3) develop and test a sequential sampling plan as a procedure for reducing sampling costs.

The monitoring methods tested were of two types: counts of beetles (on the whole plant or in the ear zone); and sticky traps. Plant counts were cheaper and less variable (ie. more reliable) than sticky traps. In 1984 sampling,

the ear zone was more attractive to northern than to western corn rootworms and this introduced bias as the season progressed and the attractiveness of the ear zone changed. However, this bias was not a problem in 1985.

Combinations of type of trap, color of trap, and type of pheromone were tested in 1984 and 1985. White Pherocon® 1C traps baited with a racemic mixture of western corn rootworm pheromone caught the two species of rootworms in the same proportion that they were counted on whole plants. Twenty fields were monitored with pheromone traps in August 1985. However, catches were profoundly affected by temperature and the pheromone was too expensive to warrant further use of this monitoring method.

Because counts of rootworm beetles per whole plant best met the requirements of speed, reliability and cost of estimates, sequential sampling of whole plants was investigated to further reduce sampling costs with this method. Three sequential-sampling plans were developed using plant counts made in 1984. These plans were tested in 20 fields in August 1985 and the treatment decisions made with all of them in each field agreed with those made after sampling 60 plants. However, only Waters' method of sequential sampling significantly reduced the number of samples required to make the decision. With Waters' method, the number of samples was reduced by 55% in first year fields and 48% in second year fields. This represents a significant reduction in the cost of making management decisions in corn fields and this method will be recommended for use in Ontario's Pest Management Program for field corn.

#### B) Development of economic thresholds for corn rootworms in Ontario field corn. (C.R. Ellis and B. Beattie)

Pest management in field corn not only requires a good monitoring program as described in the previous summary, but also guidelines for interpreting the need for treatment. The objective of the research reported here was to relate damage by rootworms in corn fields to numbers of rootworm beetles present in these fields the previous August. To do this, beetles were monitored in corn fields (10 first year, 10 second year, and 10 older corn fields) in August 1984 using the techniques described. In 1985 the lodging of corn plants because of rootworm attack, and the yield of grain corn was determined from rootworm treated and control areas in the fields. These are the first data on this part of the project and the results discussed below should be considered tentative.

Of the 23 fields where detailed yield comparisons were obtained, only 3 had significant ( $P < 0.05$ ) damage. Normally pest management programs rely on a good correlation between numbers obtained by sampling and subsequent damage, but like in the USA corn belt, this was not obtained in Ontario. Even though there is a poor relationship between beetle numbers and yield, pest management can still be effective by identifying fields that will not have a problem because there are too few beetles laying eggs to result in a problem even with optimum survival. All we can say about the remaining fields is

that there is a potential problem depending on many other factors including the actual number of eggs laid, their winter survival and success in establishing on the corn roots. In 1985 the lowest number of beetles that resulted in economic damage was three beetles per plant. In order to use this threshold as a basis for not treating field corn, several years of data must be obtained in fields throughout southern Ontario. In the meantime we recommend being safe and only recommending not to treat when there is less than one beetle per plant; the lowest threshold used anywhere in the corn belt for making pest management decisions.

The prognosis for pest management to have an impact on pesticide use in field corn is good. Even if our highest no-damage level turns out to be 1 beetle per plant, our sampling in 1984 and 1985 indicates that by sampling 2 first year corn fields for adults we could recommend not treating one of them in the second year of corn production.

The beetle numbers in most second and third year corn fields were above the safe threshold of 1 beetle per plant. However, no damage occurred on over half of the fields that were above this threshold. In short, at the present time a decision not to treat can be made on only a small proportion of fields, and the type one errors are high. Both of these conditions mean we can not get a return on our investment in sampling at the present time. To have an impact on older corn fields, where beetle numbers are high, we need more data as to what happens between oviposition and damage. Perhaps type 1 errors can be reduced in these fields and sampling made more practical.

#### 7. CHIDIAC, P. and GOLDBERG, M.T. - Genotoxicity of captan and related compounds in the murine duodenum.

A novel, in vivo assay was developed for the detection of small intestine carcinogens, using as an endpoint nuclear aberrations (NA), which are made up of micronuclei and apoptotic bodies, in the crypt cells of the duodenal epithelium. X-irradiation, 1,2-dimethylhydrazine (DMH), benzo(a)pyrene-(B(a)P), and N-methyl-N-nitrosourea (MNU), induce tumors in the small intestine. Each of these agents led to a substantial dose-related increase in NA incidence over baseline 24 hours after being administered to mice. Benzo(e)pyrene and methylurea, which are non-carcinogenic structural analogs of B(a)P and MNU, respectively, did not induce NA. Based on these results, it was concluded that the ability of an agent to induce NA in the small intestine was reflective of its oncogenic potential in that organ.

The fungicide captan, which is a weak duodenal carcinogen, was tested under a variety of conditions using the nuclear aberration assay. Even when administered in massive doses (up to 4000 mg/kg), captan failed to induce NA in duodenal crypts. Captan is detoxified by thiols, such as the tripeptide glutathione (GSH), the most abundant intracellular thiol. Depletion of GSH in the duodenal epithelium with L-buthionine-S,R-sulfoximine followed by large doses (up to 4000 mg/kg) of captan (94% pure) did not induce NA in duodenal crypts.

The assay was also used to study the genotoxicity of captan impurities in the murine duodenum. Samples of captan with purity ranging from 50% to 99% were compared for ability to induce NA. None of these samples (up to 2000 mg/kg) induced NA. 1,2,3,6-Tetrahydrophthalimide (THP) and bis-(trichloromethyl)-disulfide, two chemicals which have been identified as captan impurities, were also tested in the assay. THP (up to 3000 mg/kg) did not induce NA. Although a significant variance was found among bis-(trichloromethyl)disulfide treated (up to 100 mg/kg) animals and controls ( $F=5.31$ ,  $df=3,20$ ,  $p<0.01$ ), there was no dose-response effect on NA. It was concluded that the compound did not induce NA. This assay could be used to study captan impurities and breakdown products more extensively.

8. HALL, J.C. and STEPHENSON, G.R. - Lateral movement of 2,4-D and mecoprop from grassy inclines.

This project was funded in early 1986. Objectives are:

A) To determine the potential for 2,4-D and related herbicides to move laterally down grassy inclines with surface runoff water. This study will include the effects of: 1) herbicide formulation (ester versus amine); 2) slope steepness; 3) time and amount of rainfall after herbicide application; and 4) time and amount of runoff water after herbicide application.

B) To create a mathematical model to predict the potential runoff losses of 2,4-D and related herbicides under controlled environment and field conditions.

To meet these objectives, the project will be conducted in several phases. The first phase will be to determine the extent of 2,4-D and mecoprop runoff from turf grown in controlled environment growth rooms.

A progress report is expected in 1987.

9. HUBBES, M., SMITH, S.M., and WALLACE, D.R. - Feasibility of using releases of Trichogramma minutum for biological control of Choristoneura species.

In 1985, two releases of Trichogramma minutum were made against the spruce budworm on the 8/98 and 19 July near Hearst, Ontario. Parasites were released at 3, 6, and 12 million females/ha. Based upon previous studies, the releases were timed to synchronize with budworm oviposition. Emergence of budworm moths was accurately estimated from larval samples collected in June and incorporated into a developmental model. Peak moth flight occurred between 23 July and 2 August with moths present in the field until 8 August. The first egg mass laid on natural foliage was reported on 14 July. Peak ovi-

position (egg masses/g foliage) did not occur, however, until 26 July with fresh egg masses being laid until 4 August.

Maximum parasitism of fresh spruce budworm egg masses following the first release was 41, 51, and 83% for release rates of 3, 6, and 12 million females/ha, respectively, while parasitism following the second release remained relatively constant throughout the sampling period, never exceeding 26, 51, and 59%, respectively. As a result of these releases, final parasitism of viable spruce budworm eggs laid naturally averaged 16, 24, and 30% at 3, 6, and 12 million females/ha, respectively. These values compare with 0.2% parasitism of natural spruce budworm eggs on two control plots.

In 1984, using the same release strategy of 12 million females/ha as in 1985, final parasitism averaged 81.2%. This resulted in an 80% reduction in larval populations the following spring. The low overall parasitism observed in 1985 was due to a number of factors: 1) cool (July mean of 16.3°C), wet (July total precipitation of 162.5 mm) weather conditions slowing budworm emergence and oviposition; 2) lack of control over the timing of the application; and 3) poor quality of the parasites provided for the second release. The production and maintenance of parasites with a consistent quality was identified throughout this study as a key area for future research.

Point releases of 5,000 and 15,000 female T. minutum were made against Jack pine budworm on 15 and 18 September 1985, respectively, near Sault Ste. Marie, Ontario. The parasites were released at ground level in equal numbers under ten year old Jack pine (N=7) and white spruce (N=3). Overall parasitism was not significantly different between the two tree species, however, dispersal varied slightly; parasites moved more quickly and to a higher level in the canopy on Jack pine than white spruce. This may be due to the sparser foliage in Jack pine and suggests that inundative releases against the Jack pine budworm would require fewer parasites than against spruce budworm. Four geographical strains of T. minutum, collected from Jack pine budworm, are currently being maintained.

Based upon the release strategy developed in the four years of this study, the cost of using T. minutum in inundative release against the spruce budworm was estimated to be about \$6,000.00/ha. This compares to the current cost for chemical control of \$26.00/ha. Because of the number of parasites required under forest conditions and their high cost of production, releases of T. minutum would not, at the present time, be feasible for control of the spruce budworm. These releases, however, do have a significant biological impact upon the budworm. With improved production, through diversified markets and a better quality of parasite, the costs will be reduced. This, plus the fact that T. minutum is an environmentally safe, biologically active agent parasitizing a number of pest insects gives it good potential for use in integrated control programs in both forestry and agriculture.

10. JARVIS, W.R. and BARRY, J.W. - Integrated control of powdery mildew in the greenhouse.

Primary control of Sphaerotheca fuliginea is by tolerant cultivars, but available cultivars are not liked by Ontario growers, partly because they are unfamiliar and no comparative trials have been done. Biological control is achieved by the hyperparasite Ampelomyces quisqualis, with conidial sprays interspersed by water sprays, which also control the disease when used alone. Populations of antagonistic microorganisms are enhanced by spraying with microbial nutrients, such as glucose and peptone, with the addition of glycerol. Glycerol alone exerts some control by a mechanism not yet understood. Neither form of biological control is registered and judging by the draft Guidelines for Registration of Microbial Pesticides, it may be some considerable time before they are. Illegal residues of dinocap did not occur 3 days after application, and no phytotoxicity occurs if dinocap is not tank-mixed with other pesticides. Microfine formulations of sulphur control powdery mildew at very low concentrations without phytotoxicity or detriment to Encarsia formosa. Application for the registration of microfine sulphur at 1.5 g product/L has been made under the Minor Use Program, and registration is expected to be granted. Commercial companies have agreed to label changes. Environmental control occurs at high relative humidities but prolonged leaf surface wetness invites water-dependent pathogens. With computer control of the greenhouse environment, however, environmental control of powdery mildew by foggers is feasible.

11. KAUSHIK, N.K. - Toxicity of pentachlorophenol to zooplankton: fate and effects.

A) Acute Toxicity of Two Formulations of Pentachlorophenol

A pure formulation (99%, Aldrich Chemicals, Milwaukee, Wisconsin) and a technical formulation (86%, Stanchem, Toronto, Ontario) of pentachlorophenol were obtained in May, 1985. From 28 May to 30 October, a series of acute static toxicity tests was performed for both these formulations with 3 age classes (young, juvenile, and adult) of D. magna and adult D. g. mendotae.

Test solutions were made from the stock solutions by dilution with aerated well water (pH 7.5-7.8, alkalinity  $223 \pm 4.8$  mg/L, particulate organic carbon  $1.1 \pm 0.4$ , dissolved organic carbon  $0.5 \pm 0.1$  mg/L). A test consisted of 9 treatments - eight concentrations of PCP (0.75, 1.0, 1.5, 2.0, 2.5, 3.4, and 5 mg/L) that encompassed a response range of 0 to 100% mortality - and controls with an acetone equivalent of the maximum PCP concentration. Each treatment had 5 replicate beakers with 80 ml of a given test solution and 5 daphnids were placed in each beaker for a total of 25 daphnids per treatment. The exposure durations of 24, 48, and 72 h occurred under controlled conditions with a photoperiod of 16 light h:8 dark h and a constant temperature of  $20 \pm 1^\circ\text{C}$ . The results of the acute toxicity tests were summarized by comparing the estimated  $\text{LC}_{50}$  values using analyses of variance followed by DMRT procedures.

In brief, our results showed that:

- (i) the toxicity of technical and pure PCP to D. magna young did not differ significantly.
- (ii) pure PCP was more toxic to juveniles at 48 and 72 h exposure duration than was technical PCP.
- (iii) pure PCP was more toxic to adult D. magna at all exposure durations.
- (iv) pure PCP was equally toxic to all age classes of D. magna regardless of exposure time.
- (v) D. magna young were less tolerant of technical PCP than were juvenile and adult D. magna.
- (vi) D. g. mendotae adults were much more sensitive to pentachlorophenol regardless of type of formulation than were D. magna.

We had hypothesized that the technical formulation of PCP would be more toxic to daphnids because of the presence of formulation contaminants (other chlorinated phenols and dioxins). To properly evaluate these results, we must: 1) ascertain the actual purities of the purchased chemicals, and 2) identify the contaminants. These analyses are being carried out. If the purity was not as it was stated to be, we will re-analyze the data. If our initial results are validated, then further investigations will be required. We speculate that perhaps the formulation contaminants of the technical material may either inhibit uptake of PCP by the daphnids or compete with PCP and are simply less toxic. This can be tested via radioassays with <sup>14</sup>C-labelled PCP which has already been purchased for examination of bioconcentration of PCP in daphnia.

#### B) Chronic Toxicity Tests of Two Formulations of Pentachlorophenol

A preliminary chronic toxicity study consisting of 3 treatments (0.1 mg technical - PCP/L, 0.1 mg pure - PCP/L, and acetone control) was conducted between September and December with D. magna. There were 25 daphnids in each treatment, one daphnid per beaker with 80 ml of test solution in each beaker. Experimental conditions were comparable to those in the acute toxicity tests. The test solutions were changed every second day at which time the animals were fed 2.5 mg green algae/L. The daphnids were checked daily and time to appearance of the primiparous instar, time to release of first brood, number of young produced (counted and removed daily), adult mortality, the number of moults and appearance of ephippia recorded. The experiment was terminated at 60 days. Briefly, results showed that:

- (i) it took between 6 and 7 days for the primiparous instar to appear in the brood chamber and that PCP at 0.1 mg/L did not affect this criterion.

- (ii) time to release of first brood occurred about day 12 and that PCP had no significant effect.
- (iii) individuals exposed to technical PCP produced significantly more young than those in the controls, whereas individuals exposed to pure PCP produced significantly fewer young.
- (iv) the average brood size for daphnids exposed to pure PCP did not differ from the controls; however, there were significantly larger broods produced in the technical treatment.
- (v) the decreased productivity in individuals exposed to pure PCP could be attributed to a decreased number of broods produced since longevity was also significantly reduced.

Again, we await results of tests for purity and contaminants of the chemicals for proper evaluation of the above results.

12. LAING, J.E. - Introduction of Holcothorax testaceipes (Hymenoptera: Endyrtidae) for the biological control of spotted tentiform leafminer, Phyllonorycter blancardella (Lepidoptera: Gracillariidae).

Biology of Holcothorax testaceipes

More than 10,000 larval Phyllonorycter ringoniella, parasitized by H. testaceipes were shipped to the quarantine facility at the University of Guelph by Dr. N. Sekita, Aomori, Japan. Emergence of the parasitoid from these hosts was approximately 90% and each host provided an average of 10.8 adult H. testaceipes. Although not previously recorded for this species, we suspected that H. testaceipes was polyembryonic. Serial sections and dissections of larval P. blancardella, parasitized by H. testaceipes, indicated the presence of a polygerm which began to dissociate into a number of separate embryos when the host larva reached the late third or early fourth instar. Each of these embryos subsequently developed into an adult parasitoid. Sex ratio of the broods (or all individuals from one host) indicated that 97% of 775 broods observed were either all male or all female as would be expected in a polyembryonic species. The remaining 3% were mixed (broods having a sex ratio of ca. 1:1). In subsequent experiments, the sex ratio of H. testaceipes was found to be 1.8:1. Thus, the mixed broods likely were the result of both a male egg and a female egg being laid in the same host.

As soon as we determined that H. testaceipes would readily attack and develop in P. blancardella, we determined what effect duration of cold storage would have on emergence of the parasitoid. The response observed was that of a parasitoid with considerable genetic plasticity. As the length of exposure to cold was increased from 15 to 44 weeks, the length of time to 50% emergence, when the parasitoids were held at 25°C, decreased from ca. 40 days to ca. 20 days. Similarly the duration of emergence decreased from 10 days at

15 weeks exposure to cold, to one day at 44 weeks exposure to cold. The range of variation in emergence exhibited by the parasite under various conditions simulating winter is a good indication that parasites will overwinter successfully in southern Ontario. The usual length of cold period ( $\leq 0^{\circ}\text{C}$  or under snow cover) in the release areas is 15-18 weeks. Emergence would occur over a period of 7 to 10 days under these conditions which suggests that overwintering H. testaceipes will be emerging in the field over a sufficiently long period of time to be able to list at least a portion of the ovipositional period of its host. Another encouraging result was that regardless of length of exposure to cold (15 to 44 weeks) or temperature of storage ( $5^{\circ}\text{C}$ ,  $0^{\circ}\text{C}$ ,  $-5^{\circ}\text{C}$  and out-of-doors), emergence of the parasitoid was constant at ca. 78%.

H. testaceipes emerged within four to six hours of daybreak. Mating occurred immediately upon emergence and the females were pro-ovigenic. Thus, parasitization of hosts could occur on the same day as emergence of the females. Reproduction was arrhenotokous. Brood size of H. testaceipes in P. blancardella was 10.8 individuals, the same as that in its natural host, P. ringoniella. Longevity of female H. testaceipes was similar to that of female P. blancardella: 19 days at  $15^{\circ}\text{C}$ , and 10 days at  $21^{\circ}\text{C}$ . Thus, the parasitoid should be present in the field for a sufficient length of time to find hosts.

The threshold temperature for oviposition was  $15^{\circ}\text{C}$ ; the optimum temperature range for oviposition was  $21-25^{\circ}\text{C}$ . Potential fecundity was 30 eggs per female; actual fecundity was 14 eggs per female. (The latter figure may be lower than attained in the field due to confinement in the laboratory where superparasitism occurs and kairomones can influence the performance of the parasitoids.) Since the average brood size is 10.8, then the potential progeny produced by H. testaceipes will be 150 to 325 individuals per female.

#### Developmental Rates

In order to assess the synchrony of H. testaceipes with P. blancardella, thermal thresholds for development and heat unit accumulations were determined for H. testaceipes and compared to those of the host. The values for H. testaceipes were  $200^{\circ}\text{D}_9$  in contrast to  $150^{\circ}\text{D}_6$  for P. blancardella. In the spring, P. blancardella will emerge prior to the parasitoid. In this host-parasitoid association, oviposition thresholds are more likely to play the major role in synchronizing developmental rates of the host and parasite.

#### Releases

Several releases of H. testaceipes were made during 1985 in a "minimal maintenance" orchard. Approximately 5,000 parasitized P. blancardella were released in both open field releases and sleeve cage releases. In addition, smaller numbers of parasites were released in the Simcoe area in an orchard with minimal pesticide load. Further releases and relocations are planned for 1986.

13. EVANS, P. and M. STEMEROFF - The costs and benefits of IPM on onions and carrots in Ontario.

Integrated pest management (IPM) was commercially introduced to Ontario on apples in 1969. Since then, it has been extended to vegetable production on muck soils, particularly onions and carrots.

The investment in IPM on onions in the Bradford area marshes has returned almost \$3 for each \$1 spent. Individual onion growers who have participated in the program from its inception (1979) have realized a return of almost \$8 for each \$1 personally invested. The benefit measured as a result of IPM was the degree of cost savings as a consequence of reduced spray frequencies with pest monitoring.

For the carrot IPM program, the value of cost savings were not sufficient to cover the cost of monitoring. However, this does not mean that IPM on carrots is uneconomical. Rather, that for all IPM programs, it is not correct to solely justify the economics of IPM based upon cost savings. Instead, it is necessary to include both primary benefits (cost savings) and secondary benefits.

Secondary benefits include: 1) reduction in risk of crop loss from pests as perceived by growers, 2) changes in yield and quality with IPM, and 3) reduction in the rate of development of pesticide resistance. Failure to include secondary benefits in economic evaluations of IPM may result in incorrect policy decisions regarding the extension of IPM to other crops.

It is recommended that secondary benefits from IPM be quantified for the onion, carrot, and apple IPM programs in Ontario.

14. MADDER, D.J. and STEMEROFF, M. - The feasibility of implementation of an integrated pest management program on field tomatoes in Ontario.

This project was funded in the latter part of 1985. The objective is to investigate the feasibility and economics of development and implementation of an IPM program on tomatoes in Ontario under the following categories:

1. Methods available for pest monitoring in tomatoes.
2. Methods available for the control of pests on tomatoes.
3. Economic thresholds available for pests of tomatoes.
4. Attitudes held by extension and research personnel, and growers concerning the feasibility of implementing IPM on tomatoes.
5. Economic assessment of implementing and maintaining IPM on tomatoes in Ontario, such that the potential economic returns to the program are evident.

A report is expected in 1986-87.

**15. MAKEY, S.R. and LEILI, H.J. - Weather-timed application on tomatoes for improved disease control.**

Objective

To evaluate the employment of leaf wetness and temperature recordings as an indication of disease pressure, for the purpose of effectively applying fungicides.

Method

Tomatoes were transplanted at two commercial farm locations: (a) east of Harrow on May 17, and (b) north of Leamington on May 16. They were planted in three row plots, spaced 1.5 metres apart, and 33 metres in length. All treatments were replicated 4 times, in a randomized complete block design. The fungicides were applied according to the times indicated at 250 p.s.i., with a hydraulic boom sprayer. Spray applications were timed, using the "FAST" program, the S-Model, developed by A.A. MacNab and S.P. Pennypacker, Penn State University. This program is a method of monitoring leaf wetness and temperature in order to indicate periods of high disease pressure. A leaf wetness and temperature probe was manufactured at R.C.A.T. from a design developed by T.J. Gillespie, and G.E. Kidd, University of Guelph. At each location, hourly leaf wetness durations and temperatures were recorded and stored, using a Datapod, Model DP-223. Disease Severity Indices (DSI) were calculated from planting through to harvest. Assessment were taken by visually rating the foliar damage caused by Early Blight beginning in July, and at weekly intervals through to harvest. At optimum maturity, yields of marketable and unmarketable fruit were obtained. At the same time, the percentage of Anthracnose in each treatment was also determined.

Results

See Tables 1, 2, and 3.

Conclusions

Harrow Plot: - weather was dry.

- foliar blights did not develop during the summer, but some did develop after a period of heavy rainfall in August.
- the August 28 foliar blight rating reflects the rapid breakdown of the foliage with no differences amongst treatments.
- substantial fruit loss due to rotting was a result of a late, heavy rainfall. Fruit rotting of this nature could not be reduced with fungicides.
- Anthracnose control was not significantly different between treatments, except in the unsprayed check. It appears that fewer sprays than the commercial spray program of 6 would be sufficient for good Anthracnose control.
- highest yields were obtained with Difolatan 480F, sprayed on a 10 day schedule, beginning on either July 11 or July 16.
- 3 applications of either Difolatan 480F, or Bravo 500, divided equally throughout the summer after DSI reached 35, performed as well as the 6 spray commercial standard.

Leamington Plot: - weather was dry

- there were no noticeable differences in foliage blights and % Anthracnose amongst any treatments.

- rainfall, late in the season, increased the collapse of the foliage, and increased fruit rots that were not controllable with a fungicide program.

- plants were heavily infected with Bacterial Canker, which had spread throughout the trial mid to late in the season.

- although yields were not significantly different, the lowest yield was observed in the non-sprayed check.

- it appears that a minimal spray program would have been sufficient for commercial tomato production.

TABLE 1. SPRAY DATES

INITIAL SPRAY INDEX PLUS SUBSEQUENT APPLICATIONS							
Leamington	Commercial Spray	June 26	July 7	July 17	July 27	Aug. 8	Aug. 16
Harrow		June 25	July 5	July 26	July 26	Aug. 6	Aug. 17
Leamington	25, then followed by 10 day	July 5	July 16	July 25	Aug. 6	Aug. 16	
Harrow	intervals	July 9	July 19	July 29	Aug. 8		
Leamington	35, then followed by 10 day	July 9	July 17	July 27	Aug. 8	Aug. 16	
Harrow	intervals	July 16	July 26	Aug. 6	Aug. 17		
Leamington	45, then followed by 10 day	July 16	July 27	Aug. 8	Aug. 16		
Harrow	29, then followed by 10 day	July 11	July 23	Aug. 1	Aug. 12		
	intervals						
Leamington	35 + 11 subsequently or	July 9	July 19	July 23	Aug. 16		
Harrow	5 days						
Leamington	35, regular rate Difolatan	July 10	July 25	Aug. 9			
Leamington	35, 2 times reg. rate Difolatan	July 10	July 25	Aug. 9			
Leamington	35, 3 times reg. rate Difolatan	July 10	July 25	Aug. 9			
Leamington	35, 2 times regular rate Bravo	July 10	July 25	Aug. 9			
Leamington	35, 3 times regular rate Bravo	July 10	July 25	Aug. 9			
Harrow	Same as above	July 16	July 31	Aug. 13			
Leamington	Check (unsprayed)						
Harrow							

TABLE 2. HARROW DATA

TREATMENTS	RATE kg ai/ha	INITIAL DSI	APPLICATION INTERVALS	TOTAL No. SPRAYS	FOLIAR BLIGHT RATING (0-10)		%	TONNES PER HECTARE		
					Aug. 14	Aug. 28		ANTHRACNOSE	FRUIT ROT	MARKETABLE YIELD
Difolatan 480F	1.4	commercial spray		6	8.5 A	6.6 A	1.8 AB	10.2 A	41.7 ABCD	
Difolatan 480F	1.4	25	10 day	4	8.6 A	6.9 A	1.2 AB	12.0 A	47.0 ABC	
Difolatan 480F	1.4	35	10 day	4	7.4 A	6.1 A	1.2 AB	9.8 A	50.4 AB	
Difolatan 480F	1.4	45	10 DAY	4	8.5 A	6.4 A	0.9 AB	10.6 A	51.2 A	
Difolatan 480F	1.4	35	DSI = 11 (5 day)	4	8.6 A	6.9 A	1.8 AB	10.0 A	39.4 ABCD	
Difolatan 480F	1.4	35	DSI = 14 (5 day)	2	8.5 A	7.3 A	1.8 AB	11.8 A	39.0 BCD	
Difolatan 480F	1.4	35	3 applications	3	8.5 A	6.5 A	1.4 AB	10.4 A	47.0 ABC	
Difolatan 480F	2.8	35	3 applications	3	8.0 A	6.1 A	1.5 AB	10.0 A	40.9 ABCD	
Difolatan 480F	4.2	35	3 applications	3	8.6 A	7.0 A	0.7 AB	8.3 A	44.1 ABCD	
Bravo 500	2.3	35	3 applications	3	8.3 A	6.6 A	1.8 AB	10.4 A	34.2 D	
Bravo 500	4.2	35	3 applications	3	8.3 A	7.1 A	2.8 BC	15.0 A	36.2 CD	
Check				0	8.5 A	6.0 A	3.9 C	13.0 A	35.8 CD	

TABLE 3. LEAMINGTON DATA

TREATMENTS	RATE kg ai/ha	INITIAL DSI	APPLICATION INTERVALS	TOTAL No. SPRAYS	FOLIAR BLIGHT RATING (0-10)		% ANTHRACNOSE	TONNES PER HECTARE MARKETABLE YIELD*	
					July 19	Aug. 5		FRUIT ROT	
Difolatan 480F	1.4	commercial spray		6	9.3 A	7.8 A	1.0 A	8.2 A	54.6 A
Difolatan 480F	1.4	25	10 day	5	9.3 A	6.8 A	0.8 A	10.2 A	52.8 A
Difolatan 480F	1.4	35	10 day	5	9.4 A	7.0 A	2.1 A	11.2 A	56.2 A
Difolatan 480F	1.4	45	10 DAY	4	9.5 A	7.3 A	1.5 A	11.4 A	54.4 A
Difolatan 480F	1.4	35	DSI = 9 (5 day)	4	9.0 A	7.0 A	1.1 A	7.0 A	56.3 A
Difolatan 480F	1.4	35	DSI = 13 (5 day)	3	9.3 A	6.5 A	2.6 A	10.9 A	52.1 A
Difolatan 480F	1.4	35	3 applications	3	9.5 A	7.0 A	1.0 A	10.9 A	56.4 A
Difolatan 480F	2.8	35	3 applications	3	9.5 A	6.8 A	0.4 A	8.2 A	48.5 A
Difolatan 480F	4.2	35	3 applications	3	9.0 A	7.0 A	0.4 A	10.3 A	45.5 A
Bravo 500	2.3	35	3 applications	3	9.0 A	7.0 A	1.5 A	7.1 A	58.5 A
Bravo 500	4.2	35	3 applications	3	9.3 A	7.3 A	2.1 A	10.0 A	65.2 A
Check				0	9.3 A	6.8 A	2.7 A	14.4 A	48.0 A

NOTE: VALUES FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT AT THE 5% LEVEL (DUNCAN'S MULTIPLE RANGE TEST). FOLIAR BLIGHT DAMAGE RATING: 0 - NO CONTROL, FOLIAGE SEVERELY DAMAGED  
(0 TO 10) 10 - COMPLETE CONTROL

16. NEALIS, V.G. - Development of survey techniques to estimate the impact of parasites on overwintering populations of the spruce and jack pine budworms.

The current infestation of jack pine budworm (Choristoneura pinus Freeman) in Ontario has emphasized the need for a well-defined sample unit which can accurately and consistently estimate budworm population densities. Estimates based on the overwintering larval stage are of particular interest for pest management because they not only reliably predict spring population levels, but can be obtained months before strategic decisions have to be made. Samples of overwintering spruce budworm (C. fumiferana Clem.) are currently the basis for forecasting budworm problems in most provinces and the techniques (washing and forcing larvae from foliage) are applicable to the jack pine budworm. Many of these overwintering budworm are parasitized by one of two common insect parasites, Apanteles fumiferanae Vier. and Glypta fumiferanae Vier. Because these parasites exit from and kill the budworm host before it reaches the damaging stages, their presence can significantly decrease the impact of the budworm on the forest.

The purpose of this study is to develop a sampling technique to estimate the proportion of overwintering budworm which are parasitized. The idea is to provide a technique which can be combined with existing survey methods to identify areas where natural levels of parasitism are high enough that stand protection by pesticide application is not necessary. This refined method of survey would not only decrease the total area to be treated, but would conserve areas where natural mortality agents such as parasites are numerous.

A pre-requisite to this objective is definition of the appropriate sample unit for the budworm host. Both sampling problems were approached by felling infested trees and examining many subunits, selected because of their position within the tree crown. Briefly, the analysis showed that neither cardinal direction nor height of the branch within the crown influenced budworm densities. Because most budworm overwinter under scales which are most numerous on woody portion of the branch, the branch tip (60 cm) was not an adequate unit: an entire branch gave more consistent estimates of density. Tree-to-tree variation was far greater than within-tree variation indicating that sampling effort should be spread over several trees.

The estimation of proportion of budworm parasitized required far fewer branch samples because between-tree variation was less significant. The intensity of parasitism by the dominant parasite, Apanteles, was highest at the top of the tree and lowest at the bottom. However, an estimate of proportion parasitized gained by mid-crown sampling represents an adequate overall estimate of parasitism for survey purposes.

Continuing research pursues the definition of the sample unit for both budworm and their parasites over a range of budworm densities. Calculation of optimal and sequential sample sizes will follow.

17. PREE, D.J. - Genetics and management of acaricide resistance in the European red mite.

Populations of European red mite selected from a culture established in the laboratory from a commercial apple orchard in 1982 showed ca. 9x resistance to cyhexatin. Initial crosses between cyhexatin R mites and cyhexatin S mites produced a strain showing ca. 3x resistance in the  $F_1$ , suggesting that resistance might be due to a single semi-dominant gene. However, back crosses to both R and S parents from the  $F_1$  produced strains inconsistent with this hypothesis. The data suggested that cyhexatin resistance was complex, ie. due to more than one gene, possibly a combination of two genes, one dominant and one recessive. Measurements of fecundity, life span, sex ratio and rate of development of cyhexatin R and S strains did not show any reproductive disadvantage associated with cyhexatin resistance. However, in a simulated populations cage test, beginning with a 1:1 ratio R:S mites, cyhexatin resistance was lost after ca. 6 generations. This may have been due largely to complexity of the inheritance.

Dicofol resistance in another population was ca. 15x. Initial test crosses between R and S populations produced a strain similar to the S strains in susceptibility to dicofol. Results of backcrosses to both parental strains further indicated that resistance was due to a single recessive gene. Fitness tests similar to those described for cyhexatin R populations indicated that dicofol resistant populations were not different from the susceptible strains. A population cage test, using an initial ratio of 1:1 R:S mites showed no reversion of dicofol resistance over 8 generations. This suggests that although dicofol resistance is inherited as a recessive gene, it can be stable within a population for long periods of time. Crosses between cyhexatin R and dicofol R strains, followed by selection with mixtures of both acaricides, produced strains showing resistance to both acaricides.

These results suggest that long term rotations of acaricides is probably the best way to manage cyhexatin and dicofol resistance, but for two different reasons. Cyhexatin R can be lost from population over time, ie. the population reverts to a susceptible level probably because of the complex genetics associated with resistance. Dicofol resistance seems stable once selected and is probably best managed by keeping the gene at low frequencies in populations. For these reasons, closely repeated applications of both of these acaricides should be avoided. One application of each per year is probably optimal.

18. SEARS, M.K. - Crop loss associated with pests of canola in Ontario.

Two experiments were established and evaluated in 1985. The first experiment was planted in an area that had been cultivated previously, and weeds were not a major factor in the growth of canola. The second experiment was established in a fallow field that had a dense stand of broadleaf weeds and grasses. It was felt that the two plots would provide a contrast to the effects of herbicide treatment.

Plots were seeded in early May. Pre-plant herbicide treatments were applied two days prior to seeding. Treatments of insecticide and fungicide were applied to the seed or furrow at planting. After emergence, insecticides, herbicides, and fungicides were applied as foliar treatments as required by the experimental design. As in the previous year, the combinations of treatments were designed to provide different levels of infestation by insects, weeds and diseases on each plot. The combinations resulted in 64 different treatments arranged in a 4x4x4 factorial design. For each pesticide group (insecticide, herbicide, fungicide), treatments were assigned as follows: no pesticides, pesticides applied at planting, pesticides applied post-emergent, pesticides applied at planting and post-emergent.

The effect of infestations by various pests were measured directly by damage due to insects (primarily flea beetles), density of weed stand and incidence of disease and indirectly by growth parameters such as plant weight and stage of development, seed weight and quality, and overall yield. Value of the harvested seed was evaluated with guidelines published by the Canadian Grain Commission.

## Results

In the first experiment, 90-95% of the variation in growth parameters and yield was explained by the presence or absence of insecticide treatments. Damage by flea beetles was greatest in the nontreated plots, intermediate in the plots treated with carbofuran (Furadan® granular) at seeding, and the least in plots treated with foliar sprays of carbofuran or with a combination of granular and foliar application. Weed cover did not exceed 10% in any plots and disease was not noted in any plots.

A poor stand after germination reduced yields considerably in all treatments. Plants from plots treated with foliar sprays or with a combination of granular and foliar insecticides weighed nearly twice as much as nontreated plants and reached the bud stage of development 3-5 days earlier. Yields from these plots were 40-50% greater than from those in nontreated plots, and returned from \$115 to \$140 per hectare more than the nontreated plots.

In the second experiment, 55% of the variation in yield and 95% of the seed quality were explained by herbicide use. Weeds covered an average of 54% of the nontreated plots and 27% of the plots treated with a combination of herbicides at planting and after emergence. Yields in all plots were reduced by poor germination and in some plots by severe damage by groundhogs. Seed yield was 42% greater in plots treated with atrazine prior to planting and 84% greater in plots that were treated with a combination of atrazine prior to seeding and a post-emergent treatment. Plots treated with herbicide returned from \$50 to \$150/ha more than nontreated plots.

19. SEARS, M.K. - Thresholds of Colorado potato beetles and potato leafhoppers on potatoes.

Reduction in yield in crop plants caused by the feeding behavior of insect populations is an important parameter in establishing pest management techniques. Foliage-feeding insects often do not directly damage the marketable portion of the crop, but their activity may result in reduced yield or delayed maturation. Early damage caused by sap-feeding insects is difficult to assess, especially when symptoms may not be readily apparent. Such is the case with the potato leafhopper which causes a disruption in the vascular system that is difficult to detect in the early stages, but ultimately severely damages vegetative portions of the plant and reduces yield by as much as 40%. This effect has been recognized since 1918, but the degree to which yields were reduced was not apparent until after synthetic pesticides became available. Recent investigations have concentrated on the factors which cause yield reduction, which include reduced photosynthesis, and reduction in transport of photosynthate to developing tubers.

The ultimate goal of this investigation is to better understand the relationship between density of leafhopper populations and their effect on potato yield. This information will provide the basis for improved management techniques by commercial growers. There are currently two thresholds available in North America. Both have been developed through empirical methods; each utilizes a different stage of insect development and sampling method; and both seem to be effective only for specific regions. In the present project, experiments will be carried out under relatively controlled environments and under field conditions where factors of weather, soil type and nutrition may influence the effect of leafhopper populations.

In experiments carried out in two locations in Ontario during 1985, populations of leafhoppers did not attain sufficient densities to cause visible damage or differences in yields (Tables 1 and 2).

At the Cambridge Research Station, three of the thresholds established for potato leafhopper were exceeded, while in Mono Mills none of the thresholds were exceeded. For potato beetle adults and larvae a similar pattern existed. These data indicate the variation that exists from one location to another and underscores the need to repeat such experiments in several locations over several years in order to establish sound information regarding threshold treatments.

TABLE 1. Peak numbers of potato leafhopper adults per nymphs (PLHA/N), peak number of Colorado potato beetles (CPB eq), number of applications of insecticides, and yield of potato plots ('Norchip') at Cambridge Research Station, 1985.

Threshold	Peak <sup>a</sup> # PLHA	Peak <sup>b</sup> # CPB eq.	No. insecticide applications	Yield t/ha
>15 PLHA/N	42	-	1	17.6
>10 PLHA/N	2	-	0	15.7
> 5 PLHA/N	7	-	1	19.0
>15 PLHA/N (3 week cum.)	21	-	1	18.6
fortnightly	3	2	3	18.1
CPB eq. >12.5	-	13	2	17.2
Check	56	18	0	16.4

TABLE 2. Peak numbers of potato leafhopper adults per nymphs (PLHA/N), peak number of Colorado potato beetles (CPB eq), number of applications of insecticides, and yield of potato plots ('Norchip') at Mono Mills, 1985.

Threshold	Peak <sup>a</sup> # PLHA	Peak <sup>b</sup> # CPB eq.	No. insecticide applications	Yield t/ha
>15 PLHA/N	1.7	-	0	36.8
>10 PLHA/N	1.3	-	0	35.1
> 5 PLHA/N	1.3	-	0	31.7
>15 PLHA/N (3 week cum.)	1.5	-	0	28.2
fortnightly	1.0	0.6	3	35.2
CPB eq. >12.5	-	2.3	0	28.9
Check	1.3	2.9	0	32.4

<sup>a</sup> No. adults/25 sweeps - no. nymphs/25 haulms.

<sup>b</sup> No. adults = 1.0; no. larvae = 0.5 per 25 haulms.

20. SIDDIQI, Z. and BRAUN, H.E. - Pesticide residues in air after application for structural pest control.

This study had the following objectives:

1. To determine a safe re-entry time for the occupants of a treated building.
2. To determine the amount of pesticide residue in the air from two methods of application - Fan Spray and Crack and Crevice Treatment.
3. To determine pesticide residues in the air of apartments in highrise buildings and in single detached houses.

The following three pesticides used more commonly by the structural pest control industry were studied: (i) diazinon 1%; (ii) chlorpyrifos 0.5%; and (iii) propoxur 1.1%.

Air sampling was done at the following intervals: before spraying, during spraying (zero hour), 2, 4, 6 hours and 1, 3 and 6 days after spraying. A Nutech model 221 AC/DC gas sampler was used. Air samples were collected at a height of 1.5 m above the floor level and absorbed on 5 cm of Supelco Florisil PR60-100 mesh in a 10 cm tube at 10 litres/min. for one hour at each sampling time.

Diazinon residues in apartments in highrise buildings were collected and analyzed in 1984 and are presented in Table 1. Table 2 represents chlorpyrifos residues in apartments in highrise buildings, and results from single detached houses are in Table 3. Propoxur residues could not be analyzed from the air samples. This could be due to several factors: (i) air sampling time; (ii) type of the absorbent material; and (iii) low vapour pressure of propoxur ( $3 \times 10^{-6}$ ). Investigations are being continued to analyze propoxur residues.

TABLE 1. 1984 - DIAZINON RESIDUES IN AIR (mg/m<sup>3</sup>)  
HIGHRISE APARTMENTS (3 replications)

TIME	FAN SPRAY	CRACK AND CREVICE
1. Before spraying	ND	ND
2. Zero hour	0.0008	0.005
3. 2 hrs after	0.027	0.007
4. 6 hrs after	0.024	0.006
5. 1 day after	0.009	0.002
6. 3 days after	0.003	0.001

TLV (mg/m<sup>3</sup>): TWAEC = 0.1; STEC 0.3

TABLE 2. 1985 - CHLORPYRIFOS RESIDUES IN AIR (mg/m<sup>3</sup>)  
HIGHRISE APARTMENTS (3 replications)

TIME	FAN SPRAY	CRACK AND CREVICE
1. Before spraying	ND	ND
2. Zero hour	0.0231	0.0027
3. 2 hrs after	0.0382	0.0032
4. 4 hrs after	0.0219	0.0030
5. 6 hrs after	0.0263	0.0022
6. 1 day after	0.0168	0.0015
7. 3 days after	0.0033	0.0016
8. 6 days after	0.0037	0.0006

TLV (mg/m<sup>3</sup>): TWAC = 0.2; STEC 0.6

TABLE 3. 1985 - CHLORPYRIFOS RESIDUES IN AIR (mg/m<sup>3</sup>)  
DETACHED HOUSES (3 replications)

TIME	FAN SPRAY
1. Before spraying	ND
2. Zero hour	0.0152
3. 2 hrs after	0.0111
4. 4 hrs after	0.0127
5. 6 hrs after	0.0127
6. 1 day after	0.0082
7. 3 days after	0.0080
8. 6 days after	0.0082

TLV (mg/m<sup>3</sup>): TWAC = 0.2; STEC 0.6

The following conclusions are drawn from this study:

1. Residues of diazinon and chlorpyrifos in the air of a treated building were below the recommended TLV (less than 1/3rd).
2. More pesticide moves in the air when applied as Fan Spray than from Crack and Crevice Treatment.
3. Residues in the air peaked 2-6 hours after application, still below the TLV, irrespective of the application technique.
4. Residues in the highrise apartments declined sharply 3 days after spraying, however, in single detached houses this decline was not observed and the residues remained at a fairly constant level even up to 6 days after application.

## 21. SIDDIQI, Z. - Monitoring meadow voles in Ontario apple orchards.

The objective of this study was to monitor the meadow vole population in Ontario apple orchards and to study food preference under laboratory conditions.

The field monitoring was conducted at three locations, Inglewood, Norval and Milton. One hundred snap traps baited with a piece of fresh apple were used at each location every 2 weeks beginning September to the first snowfall. Trapped voles were observed for sex, body weight, reproductive status, stomach content, and the litter size of pregnant females. Tables 1-3 represent the field monitoring data from Inglewood. Data from Milton is presented in Tables 4-6. Meadow vole populations were extremely low at Norval and therefore monitoring was discontinued.

Laboratory investigations included food preference studies under a free choice cafeteria style setting. The 5 food choices included the 3 most common ground cover vegetations (crab grass, dandelion, and clover), fresh apple, and unpoisoned cracked corn. Cracked corn is the bait base of the most commonly used rodenticide, Waxed Mouse Bait 2 containing 2% zinc phosphide. The cafeteria style choice box was constructed out of 6 mm thick plywood measuring 28 x 60 x 25 cm with six - 10x10 cm compartments for food. There were 2 holes, 1 on each side, for voles to enter and the top of the box was covered. This choice box was placed into a larger cage, 65x95x62 cm where 6 field-collected meadow voles were maintained. This test was conducted in early October and in late November with 6 replications. Fresh food was supplied daily. The results are presented in Table 7.

In another laboratory investigation, unpoisoned cracked corn was impregnated with apple juice, and with extracts from the ground cover vegetation (clover and dandelion), to study if this impregnation would increase the acceptance of cracked corn. The results obtained are presented in Table 8.

The following conclusions are drawn from this study:

### Field Monitoring:

- (1) More male meadow voles were captured at all locations during each monitoring.
- (2) The weight of voles, especially males, declined during November-December as compared to September-October.
- (3) More pregnant females were captured during October-November.
- (4) The litter size ranged from 5 to 8 per female.
- (5) Throughout the monitoring period the stomach content of the voles was green.

Table 1:

FALL 1985	MEADOW VOLES			INGLEWOOD		
	Sept. 16	Oct. 7	Oct. 21	Nov. 4	Nov. 18	Dec. 2
Percentage Pregnant Females	-	-	100	50	-	100
Litter Size	-	-	5	5	-	6

Table 2:

FALL 1985	MEADOW VOLES			INGLEWOOD		
Reproductive Status	Avg. Weight of Voles (gm)					
	Sept. 10	Oct. 7	Oct. 21	Nov. 4	Nov. 18	Dec. 2
Males	41	37	-	36	25	26
Females	-	31	-	24	-	-
Preg. Females	-	-	-	36	-	38

Table 3:

FALL 1985	MEADOW VOLES				INGLEWOOD	
Reproductive Status	Number of Voles/100 Traps					
	Sept. 16	Oct. 7	Oct. 21	Nov. 4	Nov. 18	Dec. 2
Males	28	4	0	12	36	8
Females	0	12	0	4	0	0
Preg. Females	0	0	4	4	0	4
Juveniles	8	8	4	0	8	0

Table 4:

FALL 1985		MEADOW VOLES		MILTON	
Reproductive Status		Number of voles/100 traps			
	Sept. 23	Oct. 7	Oct. 28	Nov. 18	
Males	4	8	0	4	
Females	0	0	0	0	
Preg. Females	0	4	0	4	
Juveniles	0	0	0	0	

Table 5:

FALL 1985	MEADOW VOLES			MILTON
Reproductive Status	Avg. Weight of Voles (gm)			
	Sept. 19	Oct. 9	Oct. 29	Nov. 20
Males	31	39	-	21
Females	-	-	-	-
Preg. Females	-	43	-	49

Table 6:

FALL 1985		MEADOW VOLES		MILTON	
		Sept. 23	Oct. 7	Oct. 28	Nov. 18
Percentage Pregnant Females		-	100	-	100
Litter Size		-	8	-	6

Table 7:

FALL 1985 MEADOW VOLE FOOD PREFERENCE  
LABORATORY - FREE CHOICE

Food Choice	Average Daily Consumption/6 Voles (gm)	
	Early October	Late November
1. Apple	37 a	46 a
2. Cracked Corn	10 b	4 c
3. Crab Grass	7 b	16 b
4. Dandelion	12 b	17 b
5. Clover	12 b	9 c

Table 8:

FALL 1985 MEADOW VOLE FOOD PREFERENCE  
LABORATORY - FREE CHOICE

Food Choice	Average Daily Consumption/6 Voles (gm)
1. Cracked Corn	4 a
2. CC + Apple Juice	4 a
3. CC + Dandelion + Clover Extract	5 a

Table 9:

FALL 1985 MEADOW VOLE FOOD PREFERENCE LABORATORY	
Food	Average Food Consumption Time per Vole per Day (gm)
1. Choice (AP, CC, DN, CG, CL)	Oct. 13
	Nov. 15
2. Cracked Corn + Extracts	Nov. 2

### Laboratory Investigations

- (1) Fresh apple was significantly more preferred over the unpoisoned cracked corn and the 3 ground cover vegetations - both in early October and in late November.
- (2) During late November unpoisoned cracked corn was the least preferred food.
- (3) Acceptance of unpoisoned cracked corn was not affected by impregnation with apple juice or with extracts from the ground cover vegetation.
- (4) Daily food consumption per vole decreased significantly, from 13-15 gm/vole/day to 2 gm/vole/day, when fresh apple and green vegetation were removed and only corn was available (Table 9).

### 22. SOUZA MACHADO, V. - Efficacy and degradation of alternative herbicides to allidochlor in onions.

The control of weeds in onions has been a critical feature in the production of this crop over the last few years. The loss of valuable herbicides like niclofen (Tok®), aziprotryn (Mesoramil®) and the upcoming loss of allidochlor (Randox®) and ioxynil (Totril®) when supplies run out, have left growers with an uncomfortable feeling that their future is constantly in jeopardy. This uncertainty has not been experienced by onion growers of other regions in the world. The research project was an attempt to resolve the issue by investigating alternative herbicides that would give the desired weed control and thereby reduce the tension and uncertainty in this industry. Availability of allidochlor has since dwindled, necessitating an urgency to develop an alternative herbicide package for use on direct seeded onions on muck soils.

The 1983 program focussed attention on various rates of oxyfluorfen applied at different stages of onion seedling growth, as well as evaluating other broadleaf herbicides. Herbicide treatments using pre-emergence (pyramin, oxyfluorfen), loop stage (cyanazine, oxyfluorfen) 2 fully developed leaf and later (oxyfluorfen, pendimethalin, ioxynil, sethoxydim, fluzafop, dichlofop methyl) were evaluated on broadleaf and grass weeds. Effective weed control was recorded with cyanazine at 1.6 kg ai/ha (onion loop), pendimethalin 3.0 kg ai/ha (grass 2 leaf), oxyfluorfen 0.12 kg ai/ha (onion 2 fully developed leaf) followed by subsequent repeat applications of oxyfluorfen and later, prior to bulbing, with ioxynil at 0.45 kg ai/ha. All the grass herbicides tested proved effective. Some crop phytotoxicity was recorded with cyanazine and oxyfluorfen initially, but later the onion plants recovered.

Tolerance of onion seedlings to oxyfluorfen was evaluated in field trials and in controlled environment growth rooms. ED<sub>50</sub> values were derived by determining the dosage required to reduce by 50% the dry weight of onion seedlings sprayed at the various growth stages. Based on these values, tolerance to oxyfluorfen increased by 2 fold between the loop and flag stage, and by 14 fold between the flag and one fully developed leaf stage. Retention of oxyfluorfen spray, using a water soluble dye Eosin B, was assessed

under field and growth room conditions. Spray retention on a dry weight basis decreased about 20 and 40% between the loop/flag and flag/one fully developed leaf stages, respectively. Epicuticular wax on the surface of onion leaves on a dry weight basis increased by 28% between the loop/flag stages and by 68% between the flag/one fully developed leaf stages.

The 1984 and 1985 program focussed attention on the effectiveness of oxyfluorfen, diethatyl ethyl, CIPC and propachlor as pre- and early post-emergence herbicides, as well as documenting the weed flushes from planting up to the 2 leaf onion stage. Oxyfluorfen, diethat, CIPC and propachlor were each tested as pre-emergence herbicides, in combination with early post-emergence applications of CIPC at the loop and early 1 leaf onion stage. Broadleaf weed control up to the 2 leaf onion stage was very good with propachlor as a pre-emergence treatment, and recorded harvest onion yields equivalent to 100% of the hand weeded "check" plot. Results with oxyfluorfen and CIPC pre-emergence, recorded relative yields of 81% and 93% of the check plot, respectively. Diethatyl ethyl was effective at the pre-emergence stage to control weeds, but at the 'loop' stage was also phytotoxic on the onions. Five sequential weed flushes were recorded during the 1984 season, from onion emergence up to the 2 leaf onion stage, when the weed canopy was disturbed through the use of herbicides. Onion samples were collected for residue analysis by the OMAF Pesticide Residue Laboratory, to support future federal registration.

#### Significance of Results (to-date)

The role of oxyfluorfen (Goal®) in controlling broadleaf weeds in onions during the early establishment stage was a major priority achievement of the research program. It served to fill a vital niche at the post-emergence stage vacated by the herbicide allidochlor, which is now becoming unavailable. In a 'position' paper prepared by the Crop Protection Action Committee of the Onion Growers in January '86, they have strongly urged the Federal Government to grant the use of Goal a temporary registration for limited use in 1986, pending completion of the toxicology data for full registration review. There appears to be adequate supplies of allidochlor (Radox) for 1986, however, by 1987 supplies will be low and growers will have extreme difficulty in continuing the production of onions. Propachlor is currently the only alternative for allidochlor as a pre-emergence weed control measure. It is therefore important to allow propachlor to be used in 1986 on a research permit, to allow more residue data to be taken. Since propachlor leaves a metabolite residue in the onion bulb, if applied in July or later, it is important to have other herbicides like oxyfluorfen to continue weed control throughout the season. Without oxyfluorfen, growers have no satisfactory herbicide for broadleaf weeds between establishment of the crop and bulb formation. Ioxynil will no longer be available. Sethoxydim fills a need to control grass weeds, especially crabgrass and quackgrass not controlled by diclofop methyl.

A simple bioassay technique is being developed to evaluate propachlor activity in muck soil samples. Pre-germinated annual ryegrass is seeded in petri plates with muck soils, spiked with known concentrations of propachlor. Primary root length is recorded after 14 days and appears to be well correlated with propachlor concentrations in the range of 0.035 to 6.72 kg

ai/ha. Duplicate soil samples were also analyzed by conventional gas liquid chromatography techniques at the OMAF Pesticide Laboratory at Guelph, so as to compare results with the bioassay technique. This method when perfected, might have some field application for extension staff, so as to monitor field residues of propachlor in growers' fields.

23. **STEMEROFF, M.** - A study of the costs and benefits of herbicide use on corn and soybeans in Ontario.

This project was funded early in 1986. The objective of this study is to evaluate the benefits and costs of herbicide use on corn and soybeans in Ontario. Results from this study will complete the economic evaluation for crop protection on corn and soybeans in Ontario and will provide a base from which policy decisions regarding research priorities can be made. The economic benefits measured will include the yield and quality differential with and without herbicides, and changes in other production costs such as the harvesting cost differential between weed-free and weed-infested fields. The costs include material costs, application costs, and research and extension costs.

A final report is expected in 1987.

24. **STEPHENSON, G.R. and SOLOMON, K.R.** - Lateral movement of picloram + 2,4-D in soil.

Two different sites were prepared for this study. The first site is located near Minden, Ontario, just off County Road 16, and the second site is found just outside of the town of Limehouse, near Acton, Ontario. Each study site has 4 plots with separate trenches for collection of surface runoff water. The trenches are located at distances of 3, 10, 20, and 30 m from the spray line and are each 12 m long and approximately 0.5 m deep and wide. The length of the trenches was lined with 6 mil polyethylene sheeting to prevent water loss by drainage, and the upslope edge of the plastic was anchored into the side of the trench in such a way as to ensure that water draining off or through the top 5 to 10 cm of the soil was directed into the trench.

The sites were marked with wooden posts and sampling transects outlined. Soil samples were taken at 1 or 2 m intervals. Sampling was done systematically moving from left to right at approximately 1 m intervals at each sampling time. Sampling was also done from lowest to highest concentration, by starting at the 30 m line and working up to the spray zones. Water samples were collected from all trenches at each sampling time.

The herbicide, Tordon 101 (picloram and 2,4-D), was applied, at Minden on June 10, by a local contractor and at Limehouse on June 20, by Ontario Hydro personnel. The 101 mixture consists of 0.06 kg (0.5 lb) picloram plus 0.24 kg (2.0 lb) 2,4-D/L (gal) as amine salts. The Tordon was mixed with water at a ratio of 1 L of Tordon to 100 L of water to attain proper application

concentration. The areas of the sprayed zones varied between Minden and Limehouse with approximate total values of 1110 m<sup>2</sup> and 484 m<sup>2</sup>, respectively. There was also variability within the areas of the four spray zones of each site, with Limehouse being most consistent.

In Minden, a total of approximately 110 L of spray was applied over the 1110 m<sup>2</sup> area and at the Limehouse site a total of approximately 100 L used. In Minden, the four spray zones totalling 1110 m<sup>2</sup> were divided into primary and secondary zones; the primary zones totalling approximately 552 m<sup>2</sup> located immediately above the sampling plots and the secondary areas totalling approximately 558 m<sup>2</sup> behind the primary zones. This secondary area received only some scattered spray as a result of operational practices. This amount was therefore much smaller than that applied to the primary zones, representing perhaps only 10 L of the total 110 L sprayed. Assuming both sites received approximately 110 L of spray on the zones immediately above the plots, the following rates were applied: Picloram - 1.2 kg a.i./ha and 2,4-D - 4.8 kg a.i./ha.

Spraying was relatively consistent over all primary spray zones regardless of vegetation type or density. Spraying was also aimed upslope and confined to a height of approximately 1.5 - 2.0 m to reduce spray onto the plots. Although spraying was only done when there was no wind or when only a slight breeze blew upslope, drift was monitored at both sites. This was accomplished by placing petri plates lined with filter paper at regular intervals downslope, and immediately extracting the herbicide from the filter paper with acetone. These samples were then stored for later analysis.

Soil samples were taken prior to the application, one hour after, and at intervals of 1, 3 and 7 days, 2, 4, 7, 11, and 16 weeks following application. Additional samples will be taken in 1986, 10, 12, and 16 months after the initial application date. All soil samples were taken to a depth of 30 cm, or as deep as conditions permitted, using a sampler designed at the University of Guelph. Cross-contamination among samples was prevented by using a new PVC tube, inserted into the corer, for each sample. Samples are kept intact in the tubes and frozen until extraction.

Water samples of at least 1 L, taken in glass jars from each trench at each sampling time, were taken to the OMAF Pesticide Residue Laboratory at the University of Guelph for extraction and analysis.

The trench liners were all changed at the beginning of December to ensure that water samples taken in the spring of 1986, will not contain any residues from the summer of 1985, as a result of the herbicide binding to the plastic. The plastic liners will again be changed after the spring run-off to monitor the summer '86 samples without the chance of residues being carried over from the winter.

The slope of all plots was measured with an optical reading clinometer. The average slope of the Minden and Limehouse plots was  $18.6^{\circ} \pm 3.3^{\circ}$  and  $16.3^{\circ} \pm 1.7^{\circ}$ , respectively. The Minden plots also showed a greater within plot variability, as a result of rougher terrain.

Soil temperature and rainfall were monitored throughout the study at the Limehouse site, and for part of the study at the Minden site. Additional climatological information was obtained from local weather stations.

Analysis of the soil samples has not yet been initiated, due to difficulties with recovery efficiencies. We do, however, expect to start the extractions by early February.

Extraction of the trench water samples has been completed, and some of the samples injected, by the OMAF Pesticide Residue Laboratory. Due to problems with resolution and a malfunctioning GC detector, the samples will be re-injected after installation of a new detector. Thus, only preliminary data are available.

Preliminary results of the trench water, from days 3, 7 and 14 (the first 3 days water was collected) indicate the following trends:

Low concentrations of 2,4-D were detected in all 4 trenches at both sites after both 3 and 7 days. In all cases, between 1 and 5 ppb were detected. After 14 days, no 2,4-D was detected in any of the Minden trenches, and only a very small amount was found in the Limehouse 3 and 10 m trenches.

Picloram was detected in higher concentrations than 2,4-D in the 3 and 10 m trenches at both sites, at all 3 dates analyzed, with values somewhere between 1 and 10 ppb. No picloram was detected at any time in the 20 and 30 m trenches at the Limehouse site, and although no picloram was detected in the 20 m trench in Minden, a small amount was found in the 30 m trench at all 3 sampling dates.

More definitive statements will be possible as soon as these samples can be re-injected.

## 25. SURGEONER, G.A. - Sanitation for house fly control in dairies.

Manure management on three dairy farms having severe, moderate and low house fly populations in the Guelph area, was monitored. It was determined that most house fly maggots developing on dairy farms come from calf pens (ie. on the Davies' farm, potentially ca. 141,000 per week, from calf pens as compared to 14,000 from heifer pens and 36,000 from the manure pile). Because of poor sanitation, this resulted in counts of up to 4,500 flies in 5 minutes of counting on the Davies' farm as compared to maximum counts of 430 on our farm with moderate sanitation.

A large, inexpensive labour force is available to Ontario producers, ie. Agri-Crew, Junior Agriculturists or High School students at \$3.15/hour. Our studies indicate that once major clean up, including removal of the manure pile, has been completed (using an Agri-Crew of 4 students at \$90.00 for 1 day) sanitation can be maintained with ca. 3 hours of labour per week. It was determined that flies could develop within 8-10 days in calf manure. Thus,

from a producer perspective, clean outs must be on a weekly basis and thought of as every Tuesday morning or Friday afternoon. Using the labour pools available, excellent fly control can be achieved for ca. \$320.00/summer fly season. When producers consider their own time (clean outs would eventually be done, but less frequently) and costs of insecticides and labour to apply insecticides, overall costs are reduced. An effective economical management program for house fly control with minimum usage of insecticides (some fly baits) is possible.

26. SUTTON, J.C. - Integrated practices for managing *Botrytis* grey mold in strawberries.

The overall goals of the project are to develop practices for managing grey mold which result in little or no fungicide residues in the strawberry fruits, and to integrate the practices into a package for use by growers.

Our first objective in 1985-86 was to identify and quantify sources from which the grey mold fungus (*Botrytis cinerea*) produces the spores which infect the blossoms and fruits. Dead leaves, crowns and stolons, mummified berries, straw and soil were sampled from growers' fields near Simcoe, St. Catharines and Guelph, and from field plots at the Arkell Research Station in October 1984, May 1985 and October 1985. The samples were incubated in moist chambers to promote sporulation of *B. cinerea*. Results were similar for all sites. About 97% of spores were produced from mycelia in the dead leaves, and about 2% were produced by sclerotia in dead leaves and runners. Few spores were produced on fruit mummies (except in fall), crowns or weeds, and none were produced on straw or soil. No sexual spores (ascospores) were encountered. We conclude that the target inoculum sources are the dead strawberry leaves.

For our second objective, we monitored grey mold continuously throughout the year. Disease peaks on dead leaves occurred beneath snow cover in winter and after renovation in August. At the peaks over 50% of the leaves produced spores. Disease oscillated at a low level during April to July and September to November. We conclude that target populations of the fungus in the dead leaves are at low points when fungicides are applied in fall or spring.

Our third objective was to evaluate effectiveness of fungicides, applied in the fall or before blossoming in spring, in managing grey mold on the fruits in June. Myclobutin applied in September and October, or in April managed fruit rot as effectively as captan applied three times at blossoming during May and June. No myclobutin residues were recovered from the fruit, but 3.4 to 3.7 mg/kg of captan were found. Bravo® applied in fall or early spring reduced spore production on dead leaves at blossoming, but reductions in berry rot were not significant. Bravo residues were extremely low (0.006 to 0.097 mg/kg). Propionic acid was ineffective, probably because of our application technique.

For our fourth objective, we examined the impact of harvesting practices in solid beds or matted rows during 1984 on spore production and berry rot in 1985. The tests were conducted in collaboration with Dr. A. Dale at the

Simcoe Horticultural Research Station. Dead leaves harvested on 7 or 22 May 1985 from plots which had been hand-picked in the previous year yielded about ten times as many spores as plots which had been machine harvested (a process which removes most of the foliage). Incidence of grey mold fruit rot in mechanically harvested berries in 1985 was 62-64% in plots hand-picked in 1984 and 31-33% in plots which had been machine harvested in 1984. Bed type had no effect. We conclude that mechanical harvesting during one season suppresses grey mold in the next season, presumably by removing substrates for the grey mold fungus.

27. TEAL, P.E.A. and QUIRING, D.T.W. - Development of semiochemical based trapping methods for control of chrysomelid beetles.

The following report summarizes the results of studies conducted in field corn, sweet corn and cucurbits during the 1985 field season. Studies conducted in field corn were performed near Harrow, Ontario, while studies in sweet corn and cucurbits were carried out at the University of Guelph and Cambridge Research Station, respectively.

Summary of Results:

- 1) Western corn rootworm males are capable of mating on the first day following emergence and more than once. Therefore it is necessary to trap females rather than males because all females could potentially mate even if 92% of the males were trapped out of the population.
- 2) Trapping studies using traps baited with pheromone, pheromone plus host plant, or host plant alone did not reduce the number of beetles per plant or increase fruit production in cucurbit plots. This may be due to the inefficient traps used in this study because beetles escaped easily from, the Lingren traps used.
- 3) Of the 4 trap types assessed the best in terms of number of beetles caught per trap was the Multiplier trap which caught at least 2 times the number of beetles of both species than did other trap designs. Perocon 1C traps discriminated in favour of western corn rootworms, while Lingren funnel traps captured more northern than western corn rootworms.
- 4) Traps baited with the host plant plus pheromone, or pheromone alone, captured significantly more beetles than did either control traps or traps baited with only the host plant, in sweet corn. In cucurbits, large numbers of beetles were captured in traps baited with the host plant, pheromone, and pheromone plus host plant.
- 5) Cucurbit fields contained a higher proportion of females than did corn fields.
- 6) Ether/hexane extracts of blue hubbard squash contain an effective attractant for females of both western and northern corn rootworms. This material can be used to monitor the female population in corn fields.

The results of our study have been very informative. We have learned that in order to control the beetles by mass trapping we must capture the gravid females. We feel that the Multipher trap is best suited to this task because of its efficiency, the lack of bias in the numbers of each species captured, the high capacity before overloading, and the fact that it can be used for a number of years. Finally, we believe that the best lure for these studies is the squash blossom extract and we are now in the process of identifying the active components. The use of pure synthetic compounds will greatly enhance our ability to control both the northern and western corn rootworms using mass trapping techniques.

28. TOLMAN, J.H. and McLEOD, D.G.R. - Losses in production of processing tomatoes attributable to insects, diseases and weeds.

In order to verify yield losses recorded in processing tomatoes in 1983 a similar trial was set up in London adjacent to the Fanshawe Field Station of Agriculture Canada. Six treatments (IFH, IFHoe, FH, IF, IH and O) were replicated four times in a randomized complete block design.

The winter rye cover crop on the loam soil was ploughed down in the middle of May and the ground prepared for planting. On May 22, herbicide (H) was incorporated to a depth of approximately 5 cm. On May 23 Heinz-318 tomatoes were transplanted. Plots were then monitored throughout the season.

Although feeding damage by tomato hornworm, Manduca quinquemaculata, was observed, economic insect infestations did not develop and no insecticides (I) were applied.

Ground cover by weeds, although initially somewhat uneven, averaged 76% in H-free plots within 6 weeks of trial establishment. Dominant weeds, in order of importance were lamb's-quarters, Chenopodium album L., redroot pigweed, Amaranthus retroflexus L., witch grass, Panicum capillare L. and common ragweed, Ambrosia artemisiifolia L. Pre-transplant incorporation of a tank mixture of trifluralin + metribuzin at a cost of \$76.81/ha provided very effective early season weed control; supplementary row cultivation (\$12.73/ha) plus manual weeding (\$4.00/hr) boosted the total cost of weed control in H-treated plots to \$379.54/ha. Weed control by row cultivation and hoeing only, cost \$1025.93/ha.

Although the first foliar lesions of early blight, Alternaria solani were observed as early as July 16 in fungicide (F)-free plots, generally hot dry weather prevented widespread disease development for several weeks. By August 28 defoliation, due primarily to early blight, averaged 55% in F-free plots. A hail storm on August 26 resulted in significant damage to fruit and foliage permitting widespread disease development throughout the trial. By September 6 defoliation was general across all treatments.

Tomatoes were hand picked and graded on August 16, 27, September 5 and 16. Final results were as follows:

SOURCE OF LOSS	PROGRAM APPLIED	AVERAGE MARKETABLE YIELD (tonnes/ha)	% <sup>i</sup> YIELD LOSS	VALUE PER HECTARE (\$126.67/t)	LOSS <sup>i</sup> PER HECTARE (\$)
-	(I)FH <sup>ii</sup>	65.29	-	8270.28	-
-	(I)FHoe	55.71	14.67	7056.79	1231.49
Weeds	(I)F	9.16	85.98*	1160.30	7109.98
Diseases	(I)H	56.67	13.21	7178.39	1091.89
W,D <sup>iii</sup>	O	9.69	85.16*	1227.43	7042.85

\* -  $p < 0.05$

i - loss relative to complete (I)FH program

ii - I-insecticide; F-fungicide; H-herbicide; Hoe-cultivation + hoeing; O-none

iii - W-weeds; D-diseases

Since no I were applied, results from IFH and FH plots were pooled as the treatments were identical. These pooled results are shown for treatment IFH in the above table. Failure to control weeds significantly reduced tomato yields. The value of higher yields in weed-free plots was over 18x the total cost of weed control (\$379.54/ha); extra production from F-treated plots was worth nearly 4x the cost of F application (\$278.74/ha).

## 29. TOMLIN, A.D. and WHISTLECRAFT, J.W. - Biology of the dipterous predator, Coenosia tigrina F.

### (a) Laboratory rearing and life history studies

Laboratory-reared adult C. tigrina (CT) held in small cages were videotaped under artificial light for 6 hours at a time to observe their mating and predatory behaviour. Female adult CT preyed on an average of nearly 0.5 onion maggots, Delia antiqua (Meigen),/day; males preyed on onion flies at a slightly lower rate. Maximal predatory rates for CT were not attained until at least 6 hours after pupal eclosion (presumably the time required for cuticular tanning to be completed).

Virgin and multiparous females mated with approximately equal frequency (about once every 24 hrs) and length of time (about 4 minutes/mating). Circumstantial evidence also suggested that multiparous females oviposited a second clutch of eggs from multiple mating activity.

A laboratory procedure was developed enabling 6.2x increases in CT populations each generation when reared at 22°C. To achieve maximum egg production onion maggot flies, pollen, honey and water were supplied to each cage. Limiting factors included an inverse relation between fecundity and adult density (eg. average egg production of 16 and 32 eggs per female at densities of 8 and 2 pairs CT per cage, respectively), and larval survival of 45.6% when fed bisected Eisenia foetida (Savigny). Of 5 earthworm species tested, the only known natural larval host, E. rosea (Savigny), gave consistently the best larval survival but it could not be obtained in adequate numbers for rearing purposes.

Two other invertebrate species, found in an onion cull pile at one experimental site on the Thedford Marsh, Dendrodrilus rubidus (Savigny) and an Enchytraeid pot worm (species unidentified) produced promising results as potential hosts for CT larvae during rearing experiments.

Exposure of newly-hatched larvae to temperatures below 10°C for 4 weeks produced a facultative diapause. Larvae so treated survived 2 weeks freezing at -4.5°C or 6 months chilling at 1°C.

CT adults voraciously preyed on onion maggot and house fly, Musca domestica (L.) adults during separate controlled cage studies.

#### (b) Field studies

Studies to determine the invertebrate (presumably earthworm) host/prey of CT larvae were inconclusive in field experiments. Yahnke and George (1972, J. Econ. Entomol. 65: 1478-1479) showed that E. rosea (Savigny) was a larval host for CT, but we have been unable to find any of this species in the Thedford Marsh region thus far. However, dense populations of D. rubidus (Savigny) and Enchytraeidae, were detected at one site where high populations of CT adults (more than 30 adults per interception trap per week) also were found. This suggested that these invertebrates may be larval hosts for CT (see (a)).

Monitoring of adult CT populations using interception traps revealed uneven distributions across the Thedford Marsh. Detailed analysis of soil cores taken over a 5 week period from an onion cull pile at one farm site, as well as hand-sorted cores taken simultaneously from a cull pile at another farm, failed to reveal any earthworms infested with CT larvae.

Results to date suggest that CT populations have patchy distributions at the Thedford Marsh. This occurrence may be a function of suitable earthworm species distribution or the availability of prey for the very mobile adult CT.

30. TU, C.M., TURNBULL, S.A., and HARRIS, C.R. - Feasibility of using Entomophthora muscae to control selected dipterous insect pests.

Entomogenous fungi, Entomophthora spp. cause diseases in many insects. In Ontario, E. muscae is one of the most important natural control agents affecting dipterous insect pests such as root maggots and the house fly. No completely satisfactory method for E. muscae culture in vivo or in vitro has been developed. As a result, evaluation of its potential for use in integrated pest management programs has been restricted.

A simple procedure for culturing E. muscae in vivo has been successfully developed enabling production of infected house fly and onion maggot adults with minimum difficulty. In the insect, the mycelium was filamentous at first, becoming segmented to short, irregular hyphal bodies. The vegetative stage was sometimes followed by complete transition of the fungus into a mass of thick-walled spherical resting spores which replaced practically all of the insect internally. More frequently, however, the internal vegetative hyphae produced conidiophores, which burst through the body wall of the host forming layers of white conidia on its exterior. Conidia, which were produced singly on the tips of simple or branched conidiophores, were projected violently into the air in large numbers. This behavior enabled the use of a conidial shower method to infect healthy flies. Infectivity and virulence of the strain has been maintained over 9 months with both hosts. Cross-infection of the two species of flies also was successful.

It is generally accepted that E. muscae infects insects through contact and subsequent penetration by germinating conidia. Moisture and temperature are thought to play important roles in conidia germination. To evaluate RH effects, relative humidities at 100, 90, 80, 70, and 50% were maintained in small chambers using chemical solutions. Conidia, collected by placing glass slides under fresh infected fly cadavers for 30 minutes, were placed in the chambers under the different RH conditions. Conidia exposed to moisture germinated in 2 hours or less. Ninety to 100% RH at 20°C was most suitable for conidial germination. The germ tubes elongated and formed a mycelium which had far fewer branches than vegetative mycelium and which grew on energy supplied by food reserves stored in the conidium.

It is commonly assumed that an adult fly becomes infected when the exoskeleton is penetrated by conidial germ tubes. However, when E. muscae cells or conidia were fed to onion maggots or house flies in an aqueous conidial suspension, disease symptoms also developed.

In addition to maintaining E. muscae strains isolated in 1984 from diseased onion maggot flies collected in the Keswick Marsh, the vigour and pathogenicity of E. muscae strains provided by the Pasteur Institute in Paris, USDA in Ithaca, New York, and the Swiss Agronomy Research Station in Zurich, were evaluated by injection. All showed good infection.

Only a few of the many described species of Entomophthora have been grown in pure culture on artificial media. In attempts to establish E. muscae in

culture in vitro, difficulties encountered include: the demanding nutritional requirements of this species; its slow growth; and the many contaminating and usually faster growing organisms commonly associated with cadavers of E. muscae infected flies. Sabouraud-fly extract-dextrose agar was used. A culture grown on the medium selected in 1984 for this work lost its vigour and infectivity to flies and became purely vegetative. Such a pleomorphic change is well known in some human pathogenic fungi. In an attempt to overcome this problem, an insect tissue culture medium (ITCM) was employed for isolation of E. muscae. Coagulated egg yolk has been used for maintenance of cultures by some workers. Since this medium was not transparent and unfavorable to the microscopic examination of fungal growth, a tissue culture medium supplemented with fetal bovine serum and gentomycin was used as an alternative primary isolation medium for E. muscae, using fresh dead cadavers. Before the fungus had emerged from a cadaver, the body was surface sterilized and dissected. The pus-like mixture from the insect abdomen was streaked on solid medium contained in small petri dishes. Using this technique we successfully isolated and grew in vitro, 225 pure isolates of E. muscae from London, Thedford, and California flies. Infectivity of these cultures was tested by injecting flies. Eighty percent of the London strain showed good infection and of them, 30% showed quick infection. Further tests are in progress.

Although the E. muscae cultures were successfully isolated and grown using the ITCM described above, the fungus did not seem capable of forming conidia or resting spores on the medium. Although grown as a saprophyte, the fungus retained its potential parasitism when it was injected into the flies. Attempts were made to cultivate this culture on numerous different media to determine its growth and formation of conidia or resting spores. There are some reports that a fatty acid is an essential ingredient of nutrient medium for fungi; thus stearic, palmitic, capric or caproic acid were mixed in different media. Isolates were also grown on media containing different ingredients alone or in combinations with ITCM. These included: sugars, wheat extract, potato extract, glycerol, lipid (eg. butter, soybean oil, lard, corn oil, olive oil, lecithin, tween 20, tween 40, tween 60, tween 80), protein (eg. extracts of yeast, beef, pork, liver, fish, peptone, protease, neopeptone, egg yolk, egg white, human serum), plant growth hormones (eg. 2,4,D, Kinetin, gibberellic acid, indole acetic acid, naphthyl acetic acid) or manure (eg. chicken, cow, horse, pig). Cultures were also grown under different levels of oxygen concentration. Results to date indicate that vegetative growth and reproduction of E. muscae developed on different kinds of artificial media was fair in media containing fly extract + neopeptone + sucrose, wheat extract + peptone + sucrose, neopeptone + ITCM, or glycerol + lecithin + butter + ITCM, and good in media containing butter + lecithin + ITCM, butter (0.5 to 2%) + ITCM, or extracts of pork, potato, or fish.

A preliminary field study on the pathogenicity of the laboratory-produced E. muscae to onion maggot adults gave disappointing results. Onion maggot survival was low (due to natural predation) and in most tests, disease transmittal did not occur. E. muscae infections ranged from 11-30% in a few instances.

APPENDIX IV: PUBLICATIONS AND THESES RELATING TO THE ONTARIO PESTICIDES  
ADVISORY COMMITTEE RESEARCH PROGRAMS, 1985-86

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1. CHAPMAN, R.A., C.R. HARRIS, and CAROL HARRIS. 1986.  
The effect of formulation and moisture level on the persistence of carbofuran in a soil containing biological systems adapted to its degradation. J. Environ. Sci. Hlth. B21: 57-66.
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3. CHAPMAN, R.A., C.R. HARRIS, P. MOY, and K. HENNING. 1986.  
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Effect of banding and incorporation on the efficacy of granular insecticides for control of corn rootworms (Coleoptera: Chrysomelidae) in grain corn. Proc. Ent. Soc. Ont. 115: 31-36.
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7. JARVIS, W.R., and J.W. BERRY. 1986.  
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12. RODRIGUES, C.S., and N.K. KAUSHIK. 1986.  
Laboratory evaluation of the insect growth regulator diflubenzuron against black fly (Diptera: Simuliidae) larvae and its effects on nontarget stream invertebrates. Can. Ent. 118: 549-558.
13. SANDERS, C.J. 1986.  
Evaluation of high capacity, nonsaturating sex pheromone traps for monitoring population densities of spruce budworm (Lepidoptera: Tortricidae). Can. Ent. 118: 611-619.
14. SMITH, S.M., M. HUBBES, and J.R. CARROW. 1986.  
Factors affecting inundative releases of Trichogramma minutum Ril. against the spruce budworm. J. Appl. Ent. 101: 29-39.





